

ADDITIONS AND REVISIONS TO THE EARLY MIOCENE FLORA OF LIPOVANY (SOUTHERN SLOVAKIA)

VILIAM SITÁR¹ and ZLATKO KVAČEK²

¹Department of Geology and Paleontology, Faculty of Sciences, Comenius University, Mlynská dolina, 842 15 Bratislava, Slovak Republic

²Department of Paleontology, Faculty of Sciences, Charles University, Albertov 6, 128 43 Praha 2, Czech Republic

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Abstract: The site of Lipovany situated in Southern Slovakia near Lučenec has yielded new plant fossils including 1 bryophyte, 2 ferns, 2 conifers and 27 angiosperms. The vegetation corresponds to evergreen notophyllous/microphyllous broad-leaved forest suggesting subtropical humid conditions. Instead of the previous stratigraphical interpretation (Ottngangian), the age of the locality is older, i.e. the Eggenburgian according to new radiometric data. The nearest locality, Ipolytarnóc in Hungary, belongs to the same floristic complex.

Key words: Lower Miocene, Eggenburgian, fossil flora.

Introduction

The locality of Lipovany (southern Slovakia; Fig. 1) has been known since the first studies by Němejc. His first accounts (1960, 1967) were based on collections made by V. Čechovič on a surface outcrop that yielded only a limited amount of material. This Early Miocene flora was used as a parastratotype of the Ottngangian (Němejc & Knobloch 1973). In 1984, a large part of the slope was removed by a newly started sand pit and thus it was possible to gather abundant plant remains from the fossiliferous tuff and tuffite. The site has been regularly visited at various occasions, e.g. by Sitár, Bůžek and Kvaček together with the sites of Hajnačka and Pinciná (Sitár et al. 1989). Since that time, a large quantity of plant fossils have been collected by Sitár and concentrated in the Natural Sciences Faculty of Comenius University, Bratislava.

Attempts have been made to obtain cuticular remains from fresh material because some fragments looked carbonized. Preparations have not been successful with rare exceptions, because coalified fragments were fusinized due to fires during volcanic activity and not macerable. Thus the present study has been focused mostly on leaf morphological identifications, which do not always guarantee the identification of the natural limits and affinities of fossil taxa. The specimens under study will be transferred to the National Museum, Bratislava.

We were also able to revisit the original specimens of the assemblage studied by Němejc & Knobloch (1973) and attempted to comment on their identifications. Our revision also takes into account results from neighbouring localities near Ipolytarnóc (Hungary) worked out by Hably (1985). The whole volcanic complex on either side of the Slovak-Hungarian boundary corresponds floristically, although individual outcrops may differ in the quantitative composition of their flora. New radiometric data newly obtained from this complex (see below) indicate a higher age than originally expected, i.e. not the Ottngangian, but the Eggenburgian. Therefore, the flora of Lipovany can now be better employed for the correlation of continental deposits elsewhere in Central Europe.

Geographical and geological situation of the locality of Lipovany

The site is situated on the south-western margin of the Cerová vrchovina Upland, which is a part of the South Slovak Basin in a geological sense. The Cerová vrchovina Upland is built of rocks of the Early Miocene age: the Eggenburgian (Fiľakovo Formation), Lower Ottngangian (Bukovinka Formation) and Upper Ottngangian (relicts of the Šalgótarján Formation) and topped by basalts of the Cerová Formation, Pliocene–Quaternary in age (Vass & Elečko 1992).

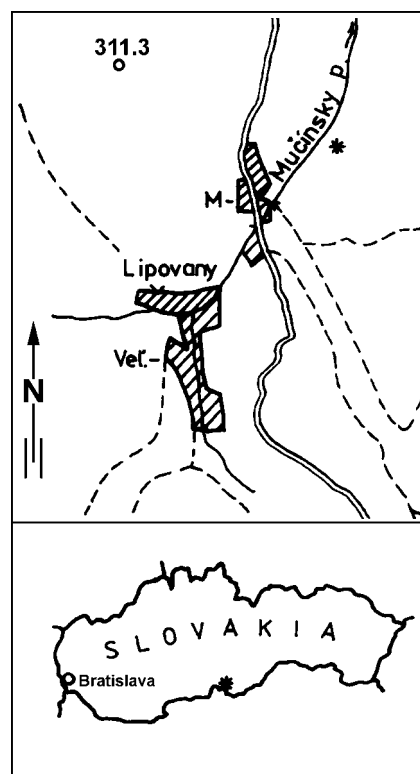


Fig. 1. Geographical position of locality Lipovany.

The studied plant assemblage from Lipovany occurs in the Bukovinka Formation. As suggested below, its age should be reevaluated to the Late Eggenburgian. The Bukovinka Formation overlies the Fíľakovo Formation, and in the north-western part of the Lučenská kotlina Depression also the Lučenec Formation. Its deposition took place after a short hiatus, its lower boundary is sharp. In places the remains of the Šalgótarján Formation (Ottngian) can be found as overlying strata. The Bukovinka Formation represents a deposition succession formed by several cycles of gravel, sand and variegated clay. Layers of rhyodacite tuff and tuffitic sandstone form intercalations within this sedimentary complex.

The site of Lipovany is situated 13 km south of Lučenec and about 1 km south-east of the village of Lipovany in southern Slovakia. It is a sand pit, in which the lower portion of the section exposes about 20 m thick layers of sand and gravel. In the upper part, firm grey rhyodacite tuffs with rich plant remains occur. Plant fossils are mostly preserved in the form of leaf impressions, coalified (fusinized) fragments and coalified or silicified tree trunks and roots. Fruits have very rarely been found.

The history of palaeobotanical research of the site started with short preliminary accounts by Němejc (1960, 1967), who listed 25 and 16 leaf forms in each, prevailing those belonging to the Lauraceae. Němejc (1967) assigned this flora to the Upper Burdigalian and interpreted the climatic conditions as warm, similar to the time interval in the Chattian-Aquitania (i.e. Egerian). A more detailed study of the Lipovany flora was published later by Němejc & Knobloch (1973) in the volume "Ottngian" of the series of Chronostratigraphy and Neostatotypes in the Paratethys. The locality Lipovany was chosen as a parastratotype locality there. Hably (1985) suggested replacing it with the site of Ipolytarnóc, but the decision of the Paratethys group had been made. In view of the new age interpretation suggested below, a problem arises, for what stage the site of Lipovany should serve.

Rögl & Steininger (1984) maintained the Ottngian to be a period of global climatic deterioration on the basis of marine faunas. The thermophile floras such as those of Lipovany and Ipolytarnóc do not correspond to this idea. Vass & Elečko (1992) attributed the Bukovinka Formation including the Lipovany locality in the Eggenburgian on the basis of the radiometric ages of rhyodacite tuffs 20.1 ± 0.3 Ma and 19.7 ± 0.2 Ma (Repčok 1987; Kantor & Wiegerová 1988) as well as on the basis of the thermophile flora.

Systematic descriptions

Hypnales

Plagiothecium sp.
Pl. I: Fig. 1

Material: 69

Impression of bryophyte cauloids very similar to the recent genus *Plagiothecium*. Leaf appendages are acute, oppo-

site, bent towards the cauloid apex. The plant might have grown on tree trunks, or on humid soil in forests or rocks.

Aspleniaceae

Asplenium sp.
Pl. I: Fig. 2

Material: 145

Fragmentary impressions of apical parts of fern fronds. Pinnulae are lobed, with a midrib and secondaries that arise under acute angles and end in the lobes. Among extant ferns, *Asplenium serpentini* Tausch. is similar in leaf morphology, although sterile remains of this sort are hardly determinable.

Blechnaceae

Woodwardia muensteriana (Presl in Sternberg) Kräusel
Pl. I: Fig. 3

- 1838 *Pecopteris münsteriana* Presl in Sternberg, p.154, Pl. 36, fig. 2.
1921 *Woodwardia münsteriana* (Presl & Sternb.) Kräusel p. 336, Pl.11, figs. 2,6–8, Pl. 12, fig. 4.
1985 *Woodwardia muensteriana* (Presl in Sternberg) Kräusel — Hably, p. 136, Pl. 2, figs. 2–5.

Material 87

Very small leaf fragment, with 2 pairs of opposite pinnules, which are fused together at the base to one third of the length. Pinnules 1 cm long and 0.4–0.5 cm wide. Midrib very delicate, secondaries hardly visible. Leaf margin slightly wavy.

Pinaceae

Pinus saturni Unger
Pl. I: Fig. 4; Pl. V: Fig. 13

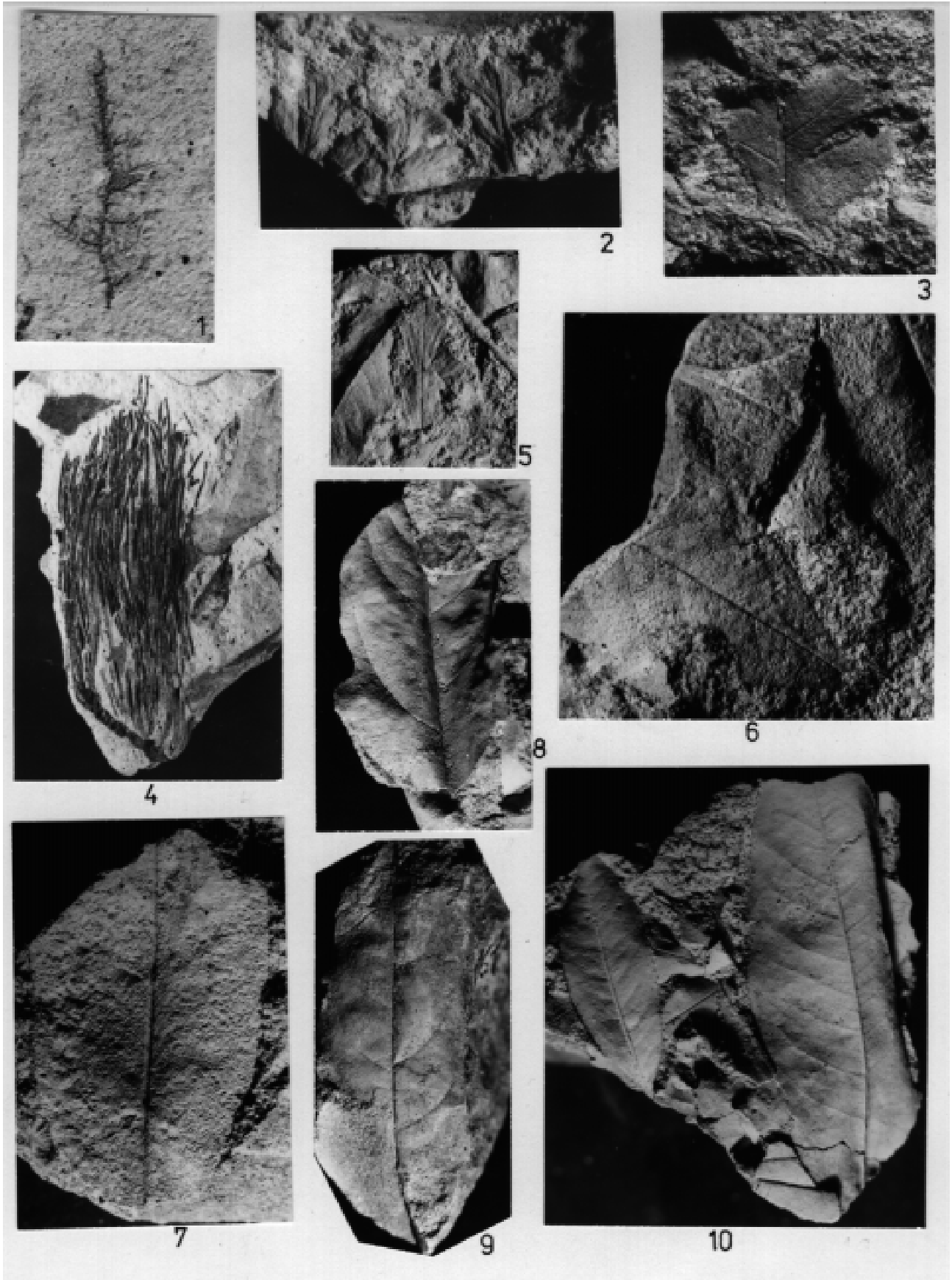
- 1847 *Pinus saturni* Ung. — Unger, p.16, pl. 4, figs. 1–3, pl. 5.
1985 *Pinus saturni* Unger — Hably, p. 84, pl. 5, figs. 1–2.

Material: 67, 140

Impressions of fragmentary leafy shoots with needle leaves in dense groups. Leaves incomplete in length of max. 7 cm are very narrow (0.5–0.7 mm across). They were probably joined in fascicles of three, which left elliptical traces on the twig.

According to Unger (1847) the leaves attained up to 17–18 cm in length. He compares this fossil species with the extant *Pinus patula* Schied. & Deppe from Mexico while Menzel (1901) with the North American *P. serotina* Mchx., *P. sabiniana* Dougl. and the Canary Islands *P. canariensis* Sm. More ex-

Plate I: Fig. 1. *Plagiothecium* sp. 3×, no. 69. **Fig. 2.** *Asplenium* sp. 3×, no. 145. **Fig. 3.** *Woodwardia muensteriana* (Presl in Sternb.) Kräusel 3×, no. 87. **Fig. 4.** *Pinus saturni* Ung., no. 140. **Fig. 5.** *Tetraclinis salicornioides* (Ung.) Kvaček, no. 55. **Fig. 6.** *Magnolia dianae* Ung., no. 13. **Fig. 7.** *Magnolia dianae* Ung., no. 12. **Fig. 8.** *Magnolia* cf. *mirabilis* Kolak., no. 163. **Fig. 9.** *Magnolia* cf. *mirabilis* Kolak., no. 161. **Fig. 10.** *Magnolia* sp., no. 109.



act relationships of detached foliage of pines are difficult to assess.

Cupressaceae

Tetraclinis salicornioides (Unger) Kvaček

Pl. I: Fig. 5; Pl. V: Fig. 12

1838 *Hellia salicornioides* Unger, p. 101, nom. invalid.

1847 *Thuytes salicornioides* Ung. — Unger, p. 11, pl. 2, figs. 1-4, 7.

1847 *Libocedrites salicornioides* (Ung.) Endl. — Endlicher, p. 175.

1985 *Libocedrites salicornioides* (Unger) Endlicher — Hably, p. 84, pl. 4, figs. 2-4.

1989 *Tetraclinis salicornioides* (Unger) comb. nova — Kvaček, p. 48, pl. 1, fig. 11, pl. 2, figs. 2-14, pl. 3, figs. 3-4, text-fig. 1.

Material: 55, 57, 137

Impressions of leafy shoots with opposite branching, consisting of 1–1.3 cm long cladode-like segments, verticilles of four fully merged dimorphic scale leaves. The segments look like a single leaf with a medial vein.

These remains are accessory fossils in the site of Lipovany. In Slovakia they occur also in the Eggenburgian of Veľká Čausa and the Upper Badenian–Lower Sarmatian deposits at Lehota pod Vtáčnikom. According to Hably (1985) the same species is known in the Upper Oligocene to Sarmatian in Hungary. The remains are also scanty there. *T. salicornioides* is regularly associated with the late mastixioid floras of Central Europe. Ecologically, it is a subtropical mesophytic element of humid climate.

Magnoliaceae

*Magnolia diana*e Unger

Pl. I: Figs. 6, 7

1850 *Magnolia diana*e Ung. — Unger, p. 442.

1861 *Magnolia diana*e Ung. — Unger, p. 26, pl. 11, figs. 1-4.

1985 *Magnolia diana*e Ung. — Hably, p. 85, pl. 5, figs. 3-5, pl. 6, figs. 2-3.

Material: 12, 13, 104

Fragmentary impressions of large elliptical leaves, narrowed to the apex and base. Judging according to incomplete remains, the maximum length was 10 cm and more. They are 4.5 cm wide. Midrib distinct, secondaries fine, camptodrome, typical of this species. Intersecondaries usually present, they are finer and reach only to one third of the leaf width.

This form species occurs mainly in the Upper Oligocene and Lower Miocene. A Sarmatian record was published by Andreánszky (1959) from the locality Szalecsi Valley in Hungary.

Magnolia cf. *mirabilis* Kolakovskij

Pl. I: Figs. 8, 9

1959 *Magnolia mirabilis* Kolakovskij — p. 38, Pl. 14, fig. 2.

1964 *Magnolia mirabilis* Kol. — Kolakovskij, p. 117, Pl. 45, fig. 1-4.

1985 *Magnolia mirabilis* Kolakovskij — Hably, p. 139, Pl. 7, figs. 1-3.

Material: 161, 163

Incomplete impressions of entire-margined leaves, 3 and 4 cm wide and preserved length of 8 and 5 cm. Venation corresponds to the description by Kolakovskij (1964) and Hably (1985). Impressions suggest coriaceous texture of leaves.

Magnolia sp.

Pl. I: Fig. 10

Material: 109

Leaf fragmentary, narrow oval, entire-margined, 4 cm wide, preserved length 8.5 cm. Midrib slightly bent, secondaries straight for the most part, densely and regularly spaced, interspaced with parallel intersecondaries, looping very near the margin. Higher-order venation hardly visible. One lower secondary vein forked.

The fragmentary nature of the specimen prevents us giving a more precise identification. It differs from the above *Magnolia diana*e by its slender shape and more regular secondary venation. A similar leaf illustrated in Némecj & Knobloch (1973, pl. 3, fig. 6) was compared with the genus *Nyssa* Gronov ex L. by these authors.

Lauraceae

Litsea ipolytarnocensis Hably

Pl. II: Fig. 1

1985 *Litsea ipolytarnocense* sp. n. — Hably, p. 143, pl. 12, figs. 1, 4, pl. 13, fig. 1-4.

Material: 128

Impression of an oval leaf, entire-margined, 9 cm long and 5 cm wide, widely cuneate at the base, apex acuminate. Venation brochidodrome, secondaries widely spaced, bent, the lower pair opposite, more distinct. Tertiaries perpendicular to the midrib within the lamina, on the outer side of the basal veins forming small loops towards the leaf margin.

Hably (1985) described exactly the same type of foliage from the site Ipolytarnóc as a new species of *Litsea*. The only impression at hand does not allow us to verify the generic identification.

Persea "speciosa" Heer

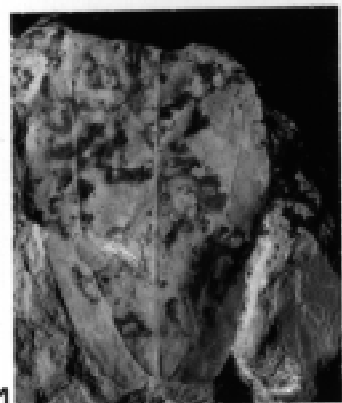
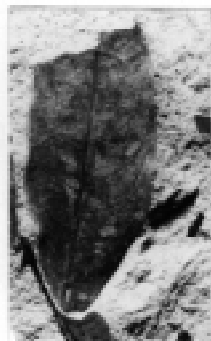
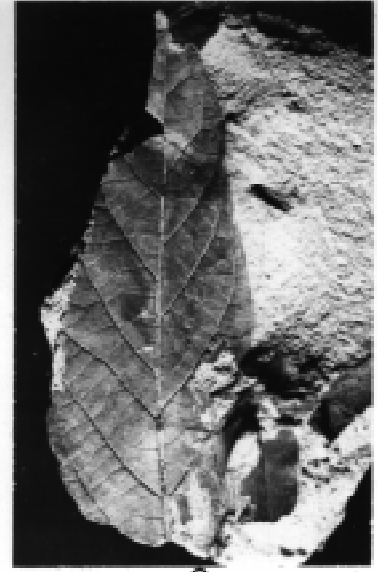
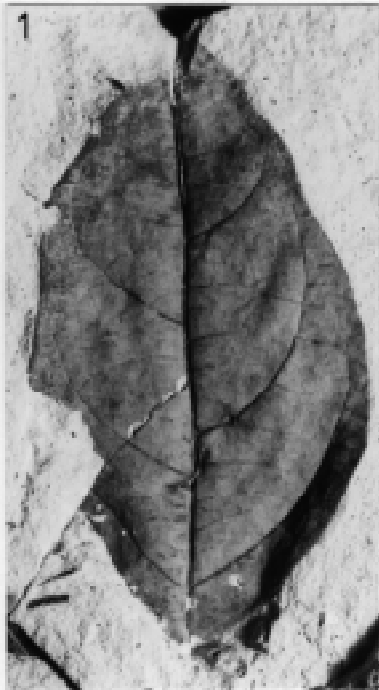
Pl. II: Figs. 2, 3

1856 *Persea speciosa* m. — Heer, p. 81, pl. 90, figs. 11-12, pl. 100, fig. 18.

Material: 35, 59, 151, 169, 192

Impressions of large lanceolate, entire-margined leaves, which are equally narrowed towards the apex and the base.

Plate II: Fig. 1. *Litsea ipolytarnocensis* Hably, no. 128. **Fig. 2.** "*Persea*" *speciosa* Heer, no. 35, *Cassia berenices* Ung., no. 33, 34. **Fig. 3.** "*Persea*" *speciosa* Heer, no. 151. **Fig. 4.** "*Laurus*" *primigenia* Ung. sensu Weyl., no. 60. **Fig. 5.** "*Laurus*" *princeps* Heer, no. 61. **Fig. 6.** "*Laurus*" *princeps* Heer, no. 165. **Fig. 7.** "*Laurus*" *princeps* Heer, no. 83. **Fig. 8.** *Laurophyllum pseudoprinceps* Weyl. & Kilpper, no. 10. **Fig. 9.** *Laurophyllum pseudoprinceps* Weyl. & Kilpper, no. 108. **Fig. 10.** *Laurophyllum* cf. *acutimontanum* Mai, no. 75. **Fig. 11.** *Daphnogene polymorpha* (Al. Br.) Ett., no. 149.



The maximum width of 3–6 cm lies in the middle of the leaf length. Although fragmentary, the leaves were quite large because fragments attain up to 7 cm in width and 20 cm of about 2/3 of a leaf. Venation brochidodrome, midrib straight or slightly bent, secondaries bent, arising under angles of 30–40° from the midrib and looping along the margin. Tertiaries form a regular polygonal network.

A very similar form was published by Hably (1985) from Ipolytarnóc under the same designation. Among the extant Lauraceae, *Persea indica* Sprengl is compared most frequently with such lauraceous leaf impressions.

“Laurus” primigenia Unger 1850 sensu Weyland 1934
Pl. II: Fig. 4

1850 *Laurus primigenia* Ung. — Unger, p. 168, pl. 40, figs. 1–4.

1934 *Laurus primigenia* Ung. — Weyland, p. 71, pl. 12, figs. 1, 3, pl. 13, figs. 2, 5.

1973 *Laurus* sp. (*“Laurus”* cf. *primigenia* Unger, 1850 sensu Weyland 1934) — Němejc & Knobloch, p. 712, pl. 5, figs. 1, 4, 6, pl. 7, fig. 4, pl. 10, figs. 2–3.

1985 *“Laurus” primigenia* Unger, 1850 sensu Weyland 1934 — Hably, pl. 15, figs. 2, 5.

Material: 60, 71, 78, 102, 119, 166, 166a

Impressions of oblong, narrow leaves, 2.6–3.5 cm. wide and 8–13 cm long, narrowed to the base and the apex. They differ from the forms of *“Persea” speciosa* by more widely spaced secondaries (in number of 5 to 7 pairs), arising at steeper angles (40°) at distances of 1.4–1.6 cm. Venation brochidodrome.

Lauroid foliage is well represented in the Oligocene and Miocene floras in Europe. Their forms are quite diverse. Thus Hably (1985) recognized 5 different taxa at Ipolytarnóc, Němejc & Knobloch (1973) even 6 of non-triveined leaves at Lipovany. Heer (1856) described as many as 7 species of *Laurus* beside similar forms of *Persea braunii* etc. Without cuticular structures the identification of various lauraceous leaves is problematic. Morphological characteristics is too uniform to be very useful in discriminating natural taxa. Therefore only most discrete form species of pinnately veined foliage of the Lauraceae are recognized herein for variable leaf impressions occurring at Lipovany. The above employed entity was revised by Ferguson (1971) on the material from Kreuzau. It shows cuticular structure different from the common *Laurophyllum pseudoprinceps* Weyland & Kilpper.

“Laurus” princeps Heer
Pl. II: Figs. 5–7; Pl. VII: Figs. 4, 6

1856 *Laurus princeps* m. — Heer, p. 77–79, pl. 89, figs. 16–17, pl. 90, figs. 17, 20.

Material: 61, 70, 72, 73, 74, 75, 79, 79a, 83, 83a, 83c, 84, 85, 105, 110, 150, 153, 160, 165, 173, 184, 193, 194, 197

Impressions of elliptic leaves, longly narrowed to the base, and apiculate at the apex (“drip-tip”), 7–9 cm long and 1.8–2.5 cm wide. Venation more regular than in the next *Laurophyllum pseudoprinceps*. Midrib straight, distinct, secondaries dense, arising at angles of 50° at the leaf base to 40° near the apex, looping along the margin.

Laurophyllum pseudoprinceps Weyland & Kilpper
Pl. II: Figs. 8, 9

1963 *Laurophyllum pseudoprinceps* Weyland & Kilpper — p. 100, pl. 6, pl. 23, figs. 14–19.

1985 *Laurophyllum pseudoprinceps* Weyland & Kilpper — Hably, p. 99, pl. 17, figs. 2–3.

Material: 6, 8, 8b, 10, 11, 21a, 53, 66, 92, 93, 108, 133, 135, 135a, 144, 181, 198

Elongate, entire-margined leaves with longly cuneate base, acute apex, about 3 cm wide and 10 cm long. Midrib straight, secondaries bent, arising at angles of 45 to 60°, at distances of 0.8–1.2 cm. In contrast to *“Laurus” princeps*, the secondaries are forked near the margin and arch-like interconnected. Tertiary venation polygonal. In rare cases fragments of leaves bear cuticle remains showing the structure of this well-defined species: adaxial anticlines with bead-like thickenings, stomata on the abaxial side amphibrachyparacytic, with broad lamella-like ledges. Hair bases have not been found.

Laurophyllum cf. *acutimontanum* Mai
Pl. II: Fig. 10

? 1963 *Laurophyllum acutimontanum* sp. n. — Mai, pro parte p. 72, pl. 8, figs. 7–19, 12, pl. 9, figs. 1–4, text-fig. 11 f–h.

Material: 16, 75, 168

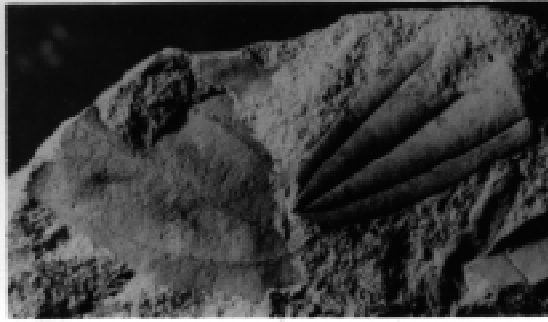
Leaves elongate/lanceolate, 6–9 cm long, 1.2–1.5 cm wide, entire-margined. Venation brochidodrome, midrib straight, secondaries widely spaced, bent, under angles of 60–45°, looping along the margin, intersecondaries frequent. Tertiary veins form polygonal meshes irregular in form and orientation. Higher-order venation distinctly reticulate. Texture thickly coriaceous.

Similar narrow lauroid and coriaceous leaves from the Late Eocene and Oligocene of Europe can be safely recognized as this entity on account of their characteristic cuticular structure (Mai 1963; Kvaček 1971). Our material lacks cuticles and thus a mere comparison based on gross-morphology can be made. Similar forms were assigned to *Laurophyllum* cf. *reusii* by Němejc & Knobloch (1973).

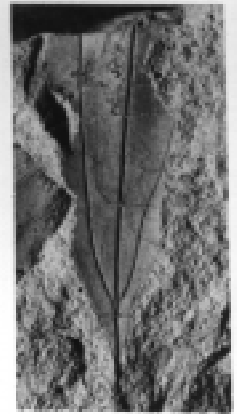
Plate III: Fig. 1. *Daphnogene polymorpha* (Al. Br.) Ett., no. 107. Fig. 2. *Daphnogene polymorpha* (Al. Br.) Ett., no. 97. Fig. 3. *Daphnogene polymorpha* forma *bilinica* Ung. comb.nova, no. 94. Fig. 4. *Daphnogene polymorpha* forma *bilinica* Ung. comb.nova, no. 138. Fig. 5. *Daphnogene polymorpha* forma *bilinica* Ung. comb.nova, no. 139. Fig. 6. *Daphnogene polymorpha* forma *bilinica* Ung. comb.nova, no. 98. Fig. 7. *Daphnogene polymorpha* forma *bilinica* Ung. comb.nova, no. 176. Fig. 8. *Daphnogene polymorpha* forma *bilinica* Ung. comb.nova, no. 127. Fig. 9. *Platanus neptuni* (Ett.) Bůžek, Holý, Kvaček no. 9. Fig. 10. *Platanus neptuni* (Ett.) Bůžek, Holý, Kvaček no. 103. Fig. 11. *Platanus neptuni* (Ett.) Bůžek, Holý, Kvaček no. 47a. Fig. 12. *Platanus neptuni* (Ett.) Bůžek, Holý, Kvaček no. 156. Fig. 13. *Platanus neptuni* (Ett.) Bůžek, Holý, Kvaček no. 3. Fig. 14. *Platanus neptuni* (Ett.) Bůžek, Holý, Kvaček no. 4.



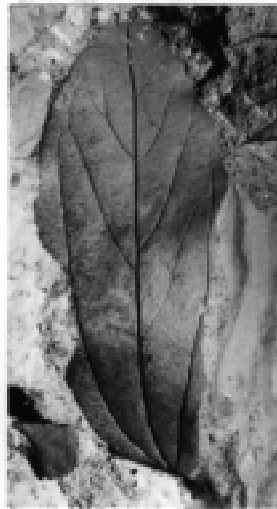
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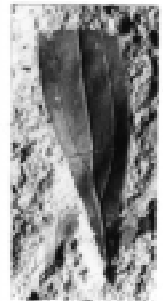
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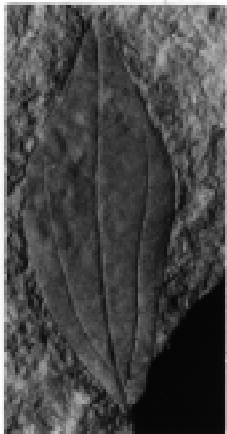
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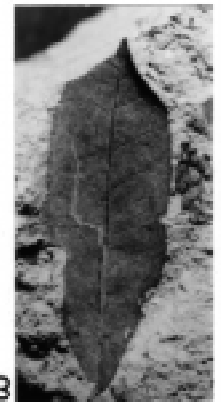
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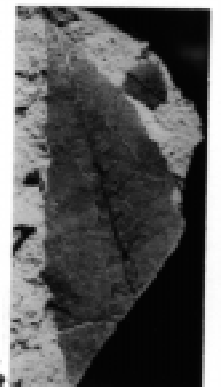
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14

Daphnogene Unger

Various views were expressed about the systematic position of the form genus *Daphnogene* versus *Cinnamomum* (Heer 1856; Depape 1922; Kräusel & Weyland 1950; Hantke 1954; Weyland & Kilpper 1963; Knobloch 1961, 1962, 1968; Kvaček 1971; Kvaček & Walther 1974 and others). The recent discovery of *Cinnamomum camphora*-allied fruits accompanying *Daphnogene* leaves at the site Kreuzau (Pingen et al. 1994) corroborate the view of Kräusel and Weyland (1950) that *Cinnamomum camphora* is the best analogue of the foliage in question. At Ipolytarnóc Hably (1985) recognized 5 different entities, Němejc & Knobloch (1973) at Lipovany three. At present we accept a more logical solution that the broader and narrower forms belong to one natural species. Therefore we do not recognize the forms as natural taxonomic units in this case.

Daphnogene polymorpha (Al. Braun) Ettingshausen
Pl. II: Fig. 11; Pl. III: Figs. 1, 2

- 1845 *Ceanothus polymorphus* A. Braun, p. 171.
1851 *Daphnogene polymorpha* (A. Braun) Ettingshausen, p. 16, pl. 2, figs. 22–25.
1973 *Daphnogene spectabile* (Heer 1856) Knobloch, 1968 — Němejc & Knobloch, p. 706, pl. 4, fig. 1, pl. 9, fig. 4.
1985 *Daphnogene cinnamomifolia* (Brongn. in Cuvier) — Hably, p. 90.
1985 *Daphnogene cinnamomeifolia* (Brongniart) Bronn — Hably, p. 90, pl. 9, figs. 2–3, text-fig. 6.
1985 *Daphnogene polymorpha* (A. Braun) Ettingshausen — Hably, p. 92, pl. 11, figs. 1–4, text-fig. 8.
1985 *Daphnogene spectabile* (Heer) Knobloch — Hably, p. 94, pl. 11, fig. 5, pl. 12, figs. 2–3, text-fig. 9.

Material: 97, 107, 134, 149

Miocene populations usually slightly differ from those of the Palaeogene by more variable foliage and also include short and broad forms. This is the case of the suite of triveined leaves from Ipolytarnóc (Hably 1985). At Lipovany broader forms are rare. They differ from the “*bilinica*” form described below by a more oval form and larger size. The width of the leaves attains more than 3 cm, the length cannot be estimated in fragments at hand. The veinlets arise from the midrib and the basal veins nearly at right angles.

Daphnogene polymorpha (A. Braun) Ettingshausen
forma *bilinica* (Unger) stat. n.
Pl. III: Figs. 3–8

- 1847 *Ceanothus bilinicus* Unger, p. 145, pl. 49, fig. 9.
1950 *Cinnamomophyllum scheuchzeri* (Heer) Kräusel & Weyland, p. 68, pl. 11, fig. 7, pl. 16, figs. 1–6, pl. 17, fig. 1, pl. 18, figs. 2–4.
1967 *Daphnogene bilinica* (Unger) comb. nov. — Kvaček & Knobloch, p. 203.
1973 *Daphnogene bilinica* (Unger) Kvaček & Knobloch — Němejc & Knobloch, p. 703, pl. 2, fig. 1, 7, pl. 3, fig. 1, pl. 8, figs. 2, 8, 9, pl. 10, figs. 1, 6.
1973 *Daphnogene cinnamomeifolia* (Brongniart, 1822) Bronn, 1853–1856 — Němejc & Knobloch, p. 705, pl. 2, fig. 3.
1985 *Daphnogene bilinica* (Unger) Kvaček & Knobloch — Hably, p. 91, pl. 9, figs. 1, 4–6, pl. 10, figs. 1–7, text-fig. 7.

Material: 56, 94, 95, 96, 98, 120, 127a, 138, 139, 147, 152, 154, 155, 157, 158, 170, 176

Impressions of elongate-lanceolate leaves, longitudinally narrowed towards the base and the apex. The size varies in the range of 4–8(–10) cm in length and 1.5–3 cm in width. The midrib is mostly straight, basal veins slightly thinner, arising at various distances from the base. They are subparallel with the margin to about two thirds of the leaf length, where they loop with the secondaries or merge with the higher-order venation.

Similar cinnamomoid forms occur in Europe starting with the Late Eocene. *Daphnogene polymorpha* forma *bilinica* occurs in Slovakia more abundantly till the Badenian, rarely also in the Sarmatian.

Platanaceae

Platanus neptuni (Ettingshausen) Bůžek, Holý & Kvaček
Pl. III: Figs. 9–14; Pl. VII: Fig. 5

- 1866 *Sparganium neptuni* Ettingsh. — Ettingshausen, p. 31, pl. 7, figs. 9–15, 17–18.
1967 *Platanus neptuni* (Ettingshausen 1866) comb. nov. — Bůžek, Holý & Kvaček, p. 205, pl. 1, figs. 1–6, pl. 3, figs. 1–4.
1985 *Platanus neptuni* (Ettingshausen) Bůžek, Holý & Kvaček — Hably, p. 101, pl. 17, fig. 6, pl. 18, figs. 1–6, pl. 19, figs. 1–5, pl. 10, figs. 1–4, text-fig. 16.

Material: 2, 3, 4, 7, 9, 47a, 49, 54, 64, 68, 83b, 85a, 99, 103, 121, 136, 156, 159, 164

Before 1967, when Bůžek et al. revised this taxon, these elongate, in the apical part bluntly toothed leaves were assigned mostly to *Bombax*, *Ceratopetalum*, *Cunonia* etc. Not all forms included into the synonymics by Bůžek et al. (1967) belong to this taxon. Leaves with less regular, nearly craspedodrome venation — *Quercus artocarpites*-type — were transferred to the form-genus *Icaciniophyllum* (Icacinaceae) by Kvaček & Bůžek (1995). Our material includes mostly typical leaf impressions about 10 cm long and 2 cm wide. The midrib is straight and starts from up to 1 cm long petiole. The leaves are slightly asymmetric at the base, acuminate at the apex. Venation semicraspedodrome, secondaries subopposite, looping at a distance from the margin. Intersecondaries regularly present. Awl-shaped blunt teeth on the margin except the entire-margined lower third of the leaf length.

Platanus neptuni was distributed in Europe starting with the Late Eocene (the type locality Kučlín), dominates in Oligocene floras of Hungary (Hably 1980; Kvaček & Hably 1991), less commonly in North Bohemia (Bůžek et al. 1967) and survives till the Miocene (Kovar-Eder et al. in press). In Lipovany, as in Ipolytarnóc (Hably 1985), *P. neptuni* is one of the dominant elements. The extant *P. kerrii* Gagnep. from SE Asia is similar in its foliage.

Juglandaceae

Cyclocarya cyclocarpa (Schlechtendal) Knobloch
Pl. IV: Figs. 1–3; Pl. VII: Figs. 2, 3

- 1896–1898 *Pterocarya cyclocarpa* Schlechtendal, p. 20–22 (102–104), pl. 4, figs. 1–3, pl. 6, figs. 2–3.
1953 *Cyclocarya cycloptera* Iljinskaja, p. 120, nom. illegit.
1956 *Cyclocarya cycloptera* (Schlecht.) Iljinskaja — Kryshtofowich, p. 80–81, pl. 9, figs. 3–4, pl. 15, fig. 3, pl. 17, fig. 8, 10, 12, pl. 18, figs. 10–14, text-fig. 25–28.

- 1961 *Cyclocarya cyclocarpa* (Schlecht.) nov. comb. — Knobloch, p. 262–264, pl. 15, figs. 5–7.
 1973 *Cyclocarya cyclocarpa* (Schlechtendal, 1896–8) Knobloch 1961 — Nĕmejc & Knobloch, p. 697, pl. 1, figs. 3, 5.
 1985 *Cyclocarya cyclocarpa* (Schlechtendal) Knobloch, p. 107, pl. 24, fig. 1, pl. 27, figs. 1–5, pl. 28, figs. 1–5, text-fig. 19.

Material: 5, 14, 15, 58, 64a, 124, 126, 171, 172, 182

The foliage at hand matches well with that of *C. cyclocarpa* described by Iljinskaja in Kryštofowich (1956) and by Knobloch (1961) from the Oligocene of Kazakhstan and North Bohemia respectively. Some of the specimens differ in the secondaries arising under angles of 45–70° from the midrib and their marginal endings. The venation in some leaflets is craspedodrome, in the others the secondaries fork and loop, sending side veinlets into teeth. Such variation has been found in *Cyclocarya* by Iljinskaja (1953). The size of leaflet impressions is difficult to assess due to their fragmentary nature. Most frequently, the leaflets are 2.5–3 cm wide and possibly as long as 6–7 cm. The specimen No. 126 is the most complete, 1.6 × 4 cm in size.

The genus was established by Iljinskaja (1953), who separated the extant *Pterocarya paliurus* Batal. (subtropical SE China at 500–2,150 m alt.) from the rest of the genus *Pterocarya* Kunth. on account of peculiar fruits with circular wing. Later Manchester (1987) found further characters that distinguish *Cyclocarya* from *Pterocarya* in floral morphology.

Cyclocarya has a long history starting with the Paleocene (Manchester 1987), *C. cyclocarpa* is spread in Europe in the Oligocene to Miocene (Mai & Walther 1991). Iljinskaja mistakenly renamed this species *Cyclocarya cycloptera* Iljinskaja, nom. superfl. This erroneous binomen is sometimes maintained by later authors (Manchester 1987).

Engelhardia orsbergensis (Wessel & Weber) Jählichen,
 Mai & Walther
 Pl. IV: Figs. 4–8, 10

- ?1852 *Xanthoxylon braunii* Weber, p. 224, pl. 25, fig. 6.
 ?1853 *Rhus prisca* Ettingshausen, p. 79, pl. 26, figs. 13–16, 20.
 1956 *Banksia orsbergensis* Wessel & Weber, p. 146, pl. 25, fig. 9a.
 1865 *Engelhardia detecta* Sap. — Saporta, p. 345, pl. 12, fig. 4.
 1973 *Engelhardia detecta* Saporta — Nĕmejc & Knobloch, p. 700, pl. 1, fig. 7, pl. 8, figs. 1, 3–4, pl. 10, fig. 7.
 1977 *Engelhardia orsbergensis* (Wess. & Web.) Jählichen, Mai & Walther, comb. n., p. 326.
 1985 *Engelhardia orsbergensis* (Wessel & Weber) Jählichen, Mai & Walther — Hably, p. 106, 148, pl. 20, fig. 5, pl. 24, figs. 3–6, pl. 25, figs. 1–8, pl. 26, figs. 1–6, pl. 27, fig. 5.

Material: 1, 18, 19, 20, 22, 29, 32, 41, 42, 47, 62, 65, 80, 81, 88, 89, 90, 91, 113, 114, 115, 116, 116a, 117, 118, 122, 123, 132, 132a, 132b, 137, 140, 146, 167, 175, 177, 183

Impressions of this type occur very abundantly in Lipovany: narrow small leaflets 2.4–6 cm long and 0.4–1.4 cm wide, with sparsely finely toothed margin and asymmetric base. Venation dense and fine, brochidodrome-semicraspedodrome, with intersecondaries. Secondaries either enter the teeth supramedially or loop along the margin. More or less complete pinnately compound leaves are rare (see Nĕmejc & Knobloch 1973).

Quantitatively the isolated leaflets are as common in Lipovany as in Ipolytarnóc (Hably 1985). We can assume that this

element together with the Lauraceae and *Platanus neptuni* dominated the vegetation in the studied area. According to Jählichen et al. (1977) the small size of the leaflets together with the associated Leguminosae gives meso-xerophytic aspects to the environments. The present distribution of *Engelhardia* Lsch. sensu amplo in subtropical humid forests of East Asia and related *Oreomunnea* in Central America contradict this assumption. The fossil *E. orsbergensis* known in Europe from the Middle Eocene to Pliocene was surely more tolerant to various kinds of climate than its modern analogues.

Engelhardia macroptera (Brongniart) Unger
 Pl. IV: Fig. 9

- 1828 *Carpinus macroptera* Brongniart, p. 48, pl. 3, fig. 6.
 1866 *Engelhardia macroptera* Brongn. sp. — Unger, p. 52, pl. 16, figs. 9–11.
 1973 *Engelhardia macroptera* (Brongniart, 1828) Ettingshausen, 1851 — Nĕmejc & Knobloch, p. 698, pl. 4, figs. 2–3, 4b.

Material: 43

Unusually small remain of a tripartite involucre, lobes about 1 cm long and 0.3 cm wide. Venation not visible on the base. A hollow space after the fruit.

Better preserved fruits of the same species have been found by Nĕmejc & Knobloch (1973) at Lipovany.

Leguminosae

Caesalpinia norica Unger
 Pl. IV: Fig. 11

- 1850 *Caesalpinia norica* Ung. — Unger, p. 187, pl. 63, figs. 9–18.

Material: 37, 186, 186a

Leaflets widely oval, slightly asymmetrical, entire-margined, truncate at the base, blunt at the apex, 1.5 cm long and 1 cm wide. Midrib thin, straight, secondaries in four subopposite pairs, bent. Higher-order venation very delicate.

This foliage of the Leguminosae matches well the type material from Sotzka (Unger 1850), but the generic identification cannot be guaranteed.

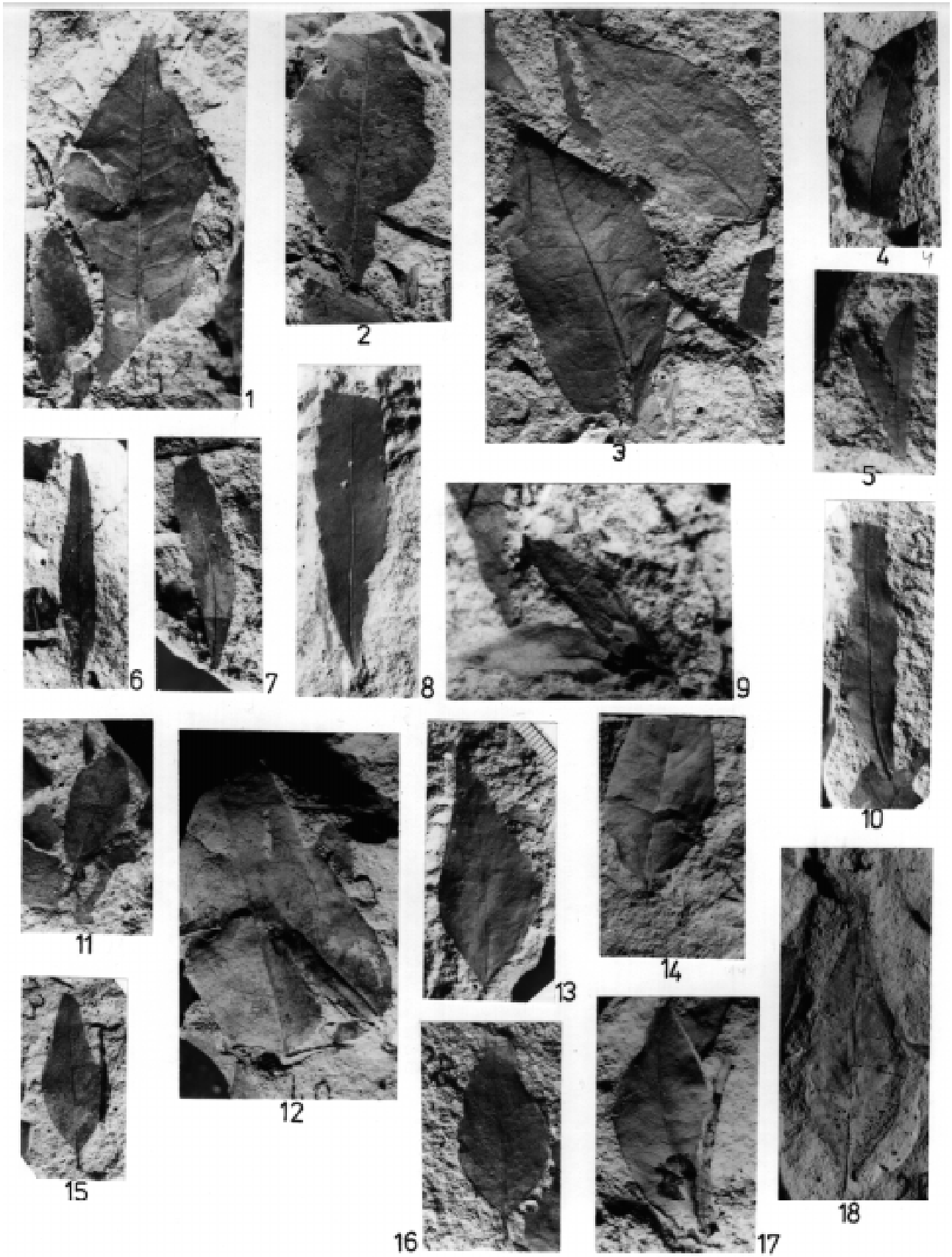
Cassia berenices Unger
 Pl. IV: Figs. 12–18

- 1850 *Cassia berenices* Ung. — Unger, p. 188, pl. 44, figs. 4–10.
 1859 *Cassia berenices* Ung. — Heer, p. 118, pl. 137, figs. 42–56.

Material: 21, 23, 24, 26, 27, 28, 30, 31, 33, 34, 36, 39, 40, 44, 45, 46, 48, 62a, 77, 82, 86, 101, 125, 129a, 174, 178, 179, 180, 187, 188

Impressions of leaflets of compound leaves, which are entire-margined, apiculate, narrowed towards the apex, cuneate at the base, the widest in the lower third of the leaf length, petiolulate (the stalk 3–5 mm long). Midrib straight, secondaries brochidodrome, very fine. Tertiaries form irregular polygonal network.

The morphological characteristics correspond best to the description of *Cassia berenices* or *C. phaseolites* by Unger (1850). The form of the lamina is also similar to *Eugenia apollinis* Unger (1850) or *Dicotylophyllum apollinis* (Unger)



Knobloch (1969). However, the extant *Eugenia ulmiflora*, which we have studied, differs in widely spaced eucamptodrome secondaries. In *Cassia*, the secondaries are dense and brochidodrome. Due to convergent morphology of foliage in Leguminosae, the generic assignment must be considered tentative. This leaf form is one of the common elements at Lipovany. Similar remain was assigned to aff. *Andromeda* sp. by Němejc & Knobloch (1973).

The species of *Cassia* thrive today in the tropics. The foliage of the extant *C. laevigata* Willdenow or *C. corymbosa* Lambert matches best our fossil material.

cf. *Cassia* sp.
Pl. V: Fig. 1

Material: 196

Leaflet widely oval, 5 cm long and 2 cm wide, entire-margined, shortly petiolulate, on the base rounded, on the apex blunt. Midrib slightly bent, secondaries irregularly spaced, the lowermost opposite, arising from the very base, higher secondaries alternate, camptodrome, looping very near the margin. Intersecondaries rare. Tertiaries widely spaced, oblique to the secondaries, partly percurrent. Higher-order venation very delicate, forming elongate areoles.

The single leaflet recalls the foliage described by Heer (1859) as *Cassia berenices*, *C. hyperborea*, *C. fischeri* and *C. phaseolites*.

Leguminosites sp.
Pl. V: Figs. 2, 3

Material: 17, 17a, 38

Leaflets narrow-oval, entire-margined, shortly petiolulate, 2.5–3 cm long, 1.2–1.5 cm wide. Midrib straight, secondaries thin and dense, arising at the angle of about 60°, looping along the margin. Tertiaries forming a very regular polygonal network.

This type of leaflets corresponds to the general type of foliage in the Leguminosae. Its more precise identification is not possible.

←

Plate IV: Fig. 1. *Cyclocarya cyclocarpa* (Schlechtendal) Knobloch, no. 5. **Fig. 2.** *Cyclocarya cyclocarpa* (Schlechtendal) Knobloch, no. 58. **Fig. 3.** *Cyclocarya cyclocarpa* (Schlechtendal) Knobloch, no. 124. **Fig. 4.** *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, no. 80. **Fig. 5.** *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, no. 18. **Fig. 6.** *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, no. 19. **Fig. 7.** *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, no. 81. **Fig. 8.** *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, no. 89. **Fig. 9.** *Engelhardia macroptera* (Brongno.) Ung. 3×, no. 43. **Fig. 10.** *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, no. 29. **Fig. 11.** *Caesalpinia norica* Ung. no. 37. **Fig. 12.** *Cassia berenices* Ung., no. 48. **Fig. 13.** *Cassia berenices* Ung., no. 27. **Fig. 14.** *Cassia berenices* Ung., no. 77. **Fig. 15.** *Cassia berenices* Ung., no. 23. **Fig. 16.** *Cassia berenices* Ung., no. 82. **Fig. 17.** *Cassia berenices* Ung., no. 45. **Fig. 18.** *Cassia berenices* Ung., no. 26.

?Icacinaceae

cf. *Icaciniophyllum* sp.
Pl. V: Fig. 4

Material: 76, 76a

Leaf impression with its counterimpression, oblanceolate, widest in the upper part, 2.3 cm wide and without its base 5.5 cm long. Margin widely finely toothed, teeth abmedially oriented. Midrib straight, secondaries first straight, near the margin zig-zag bent, along the margin connected with arches, craspedodrome or semicraspedodrome. Intersecondaries frequent, tertiaries forming polygonal meshes, higher-order venation irregularly reticulate.

Similar leaf forms with widely spaced teeth on the margin have been assigned to the Icacinaceae from the Paleogene of Central Europe (Kvaček & Bůžek 1995).

?Theaceae

Ternstroemites sp.
Pl. V: Fig. 5

Material: 106

Leaf ovate, 3 cm long, 2.2 cm wide, crenulate on the margin, base rounded, apex blunt. Secondaries in the lower part of the leaves slightly S-like, arising at an angle of 45°, in the upper part bent, steeper, near the margin many times branched, the ultimate side veinlets ending in inconspicuous (?) glandular teeth. Tertiary venation forms large polygonal meshes, irregularly oriented to the secondaries. Higher-order venation as irregular areolation. Thick remains of carbonized matter suggest coriaceous texture.

A similar type of foliage has been described in the literature under various names, but they share common features with the foliage of the Theaceae (crenulate glandular margin, complex semicraspedodrome venation, coriaceous texture). Without cuticular study a more precise identification is not possible. Similar leaf forms have been illustrated and described by Hably (1985) as *Spirea* spp. (e.g. pl. 30, figs. 4, 7) from Ipolytarnóc.

?Ebenaceae

cf. *Diospyros brachysepala* A. Braun
Pl. V: Fig. 6

- ? 1845 *Diospyros brachysepala* A. Braun, p. 170.
- ? 1859 *Diospyros brachysepala* A. Braun — Heer, p. 11, pl. 102, figs. 1–14.
- 1967 *Diospyros brachysepala* A. Braun — Němejc, p. 7.
- 1973 *Diospyros brachysepala* A. Braun — Němejc & Knobloch, p. 714, pl. 9, fig. 7.
- 1985 *Diospyros brachysepala* A. Braun — Hably, p. 110, 150, pl. 29, figs. 1–2, 6.

Material: 143, 185

Leaves oval, entire-margined, fragmentary, apex acuminate, 3–3.5 cm wide, preserved length maximum 7 cm. Venation camptodrome, midrib straight, secondaries in the lower leaf part arising at 70°, higher at angle of about 45°, bent,

widely spaced, looping along the margin, intersecondaries rare, higher-order venation hardly visible.

Similar leaves also occur at Ipolytarnóc. Hably (1985) compared associated calyx remains with *Diospyros rugosa* Saporta.

Dicotyledonidae fam. inc.

Pungiphyllum cruciatum (Al. Braun) Frankenhäuser & Wilde

Pl. V: Figs. 7–9

1850 *Quercus cruciata* Al. Braun in Stützenberger, p. 76.

1981 "*Quercus*" *cruciata* Al. Braun 1851 — Kvaček & Walther, p. 85, pl. 7, figs. 1–4, pl. 8, figs. 1–6, pl. 9, figs. 1–5, pl. 10, figs. 1–4, pl. 11, figs. 2–5, pl. 12, figs. 1, 3, text-fig. 6–7 (with more complete synonymics).

1985 "*Quercus*" *cruciata* A. Barun — Hably, p. 103, pl. 22, figs. 1–4, pl. 23, figs. 1–4, text-fig. 17.

1995 *Pungiphyllum cruciatum* (Al. Braun 1851) nov. comb. — Frankenhäuser & Wilde, p. 101.

Material: 39a, 50, 51, 52, 111, 112

The form of these enigmatic leaves varies in the number of thorny simple lobes, which may be 0–3–5 in number on either leaf side. The leaf margin is lamella-like thickened. Venation craspedodrome–camptodrome. The five specimens at hand are fragmentary, one more complete is without lobes, 7–8 cm long.

The affinities of this species remains obscure, although previously it has been assigned to *Ilex* or *Mahonia* and to *Quercus*. The American oaks of the sect. *Rubrae* (e.g. *Q. falcata* Michaux from Atlantic North America) were brought for comparison most frequently. However, the stomata do not correspond to the type found in *Quercus* or *Ilex* (Kvaček & Walther 1981). The Eocene records were separated into an independent species *Pungiphyllum waltheri* Frankenhäuser & Wilde (1995), which slightly differs by having shallowly toothed margins. *Pungiphyllum cruciatum* occurs rarely in the Oligocene and Early to Middle Miocene floras of Europe, exceptionally in the younger Neogene (Givulescu & Olos 1973; Kolakovskij 1964).

"*Celastrus*" *oxyphyllus* Unger

Pl. V: Fig. 11

1850 *Celastrus oxyphyllus* Ung. — Unger, p. 177, pl. 51, figs. 22–24.

1969 *Celastrus* cf. *oxyphyllus* Unger, 1850 sensu Ettingshausen, 1877 — Knobloch, p. 32, text-fig. 54.

Material: 25

Impression of a small coriaceous leaf, 2 cm long and 0.9 cm wide. Midrib straight, secondaries arising steeply in number of 6–7 pairs. Margin finely toothed or crenulate.

The impression is similar to the figure published by Unger (1850) on the plate 51, fig. 24. Another similar fossil was reported by Knobloch (1969) from the Early Miocene deposits near Znojmo, South Moravia. The systematic position of all these leaves remains obscure.

Dicotylophyllum sp.

Pl. V: Fig. 10

Material: 185

Fragmentary elongate entire-margined leaf, 12 cm long and ca. 3 cm wide. Midrib straight, thin, secondaries at the angle of 80°, regularly spaced, straight, looping close to the margin. Tertiaries very irregular, forming irregular meshes between the secondaries of different outlines and sizes.

The venation recalls some species of the genus *Myrica*, e.g. *M. integerrima* Kr. & Weyl. Němejc & Knobloch (1973) illustrate similar leaf impression as af. *Quercus neriifolia* Al. Braun.

Palmae

Calamus noszkyi Jablonsky

Pl. VI: Fig. 3

1914 *Calamus noszkyi* sp. n. — Jablonsky, p. 236–244, pl. 9, figs. 1–3.

1960 *Cyperites chavanensis* Heer — Němejc, p. 113.

1973 *Calamus noszkyi* Jablonsky — Němejc & Knobloch, p. 721, pl. 9, figs., 3, 6.

1985 *Calamus noszkyi* Jablonsky — Hably, p. 120, 158, pl. 35, fig. 3, pl. 36, figs. 3, 5, pl. 37, fig. 1.

Material: 32a, 148

Impressions of parallel-sided leaf segments 0.7–1.5 cm wide with parallel venation. Finer veins are interspaced with stronger veins on either side of the midrib. The complete leaf is pinnately compound, leaflets subopposite, arising from the rachis at angles of about 30°.

Hably (1985) assumes that this plant occurs very frequently in Ipolytarnóc. In Lipovany these remains are quite rare. *Calamus* is a thermophile element of humid tropical-subtropical climate.

Chamaerops helvetica Heer

Pl. VI, figs. 1, 2

1855 *Chamaerops helvetica* m. — Heer, p. 86, pl. 31–32.

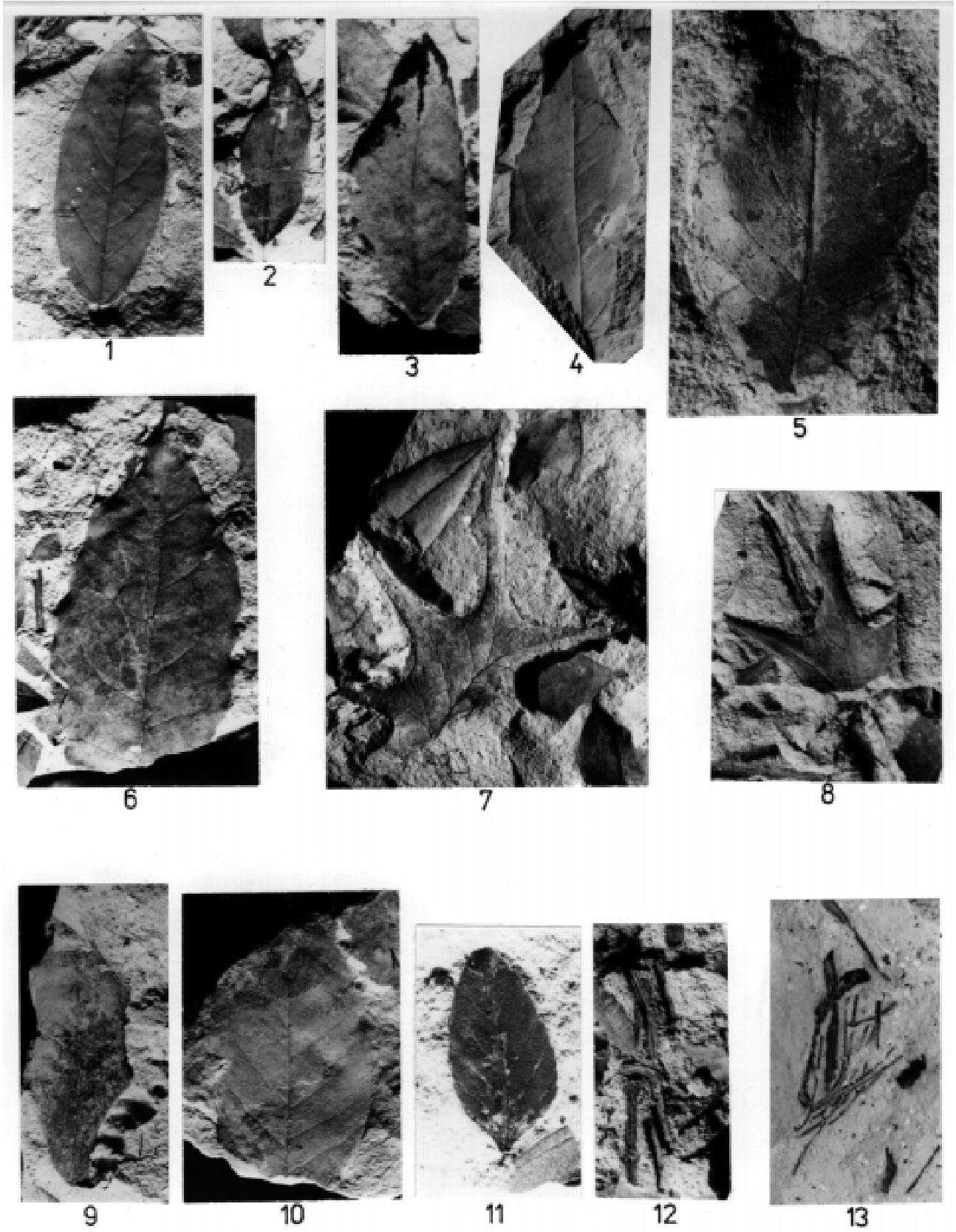
1992 *Chamaerops helvetica* Heer — Schweigert, p. 26, pl. 6, fig. 1.

Material: 130, 131, 190

Plate V: Fig. 1. *Cassia* sp., no. 196. **Fig. 2.** *Leguminosites* sp., no. 17. **Fig. 3.** *Leguminosites* sp., no. 38. **Fig. 4.** cf. *Icaciniophyllum*, no. **Fig. 5.** *Ternstroenites* sp. 2×, no. 106. **Fig. 6.** *Diospyros brachysepala* Al. Br., no. 143. **Fig. 7.** *Pungiphyllum cruciatum* (Al. Br.) Frankenhäuser & Wilde, no. 52. **Fig. 8.** *Pungiphyllum cruciatum* (Al. Br.) Frankenhäuser & Wilde, no. 50. **Fig. 9.** *Pungiphyllum cruciatum* (Al. Br.) Frankenhäuser & Wilde, no. 51. **Fig. 10.** *Dicotylophyllum* sp., no. 185. **Fig. 11.** "*Celastrus*" *oxyphyllus* Heer, 2× no. 25. **Fig. 12.** *Tetraclinis salicornioides* (Ung.) Kvaček, no. 57. **Fig. 13.** *Pinus saturni* Ung. no. 67.

Plate VI: Fig. 1. *Chamaerops helvetica* Heer, no. 131. **Fig. 2.** *Chamaerops helvetica* Heer, no. 190. **Fig. 3.** *Calamus noszkyi* Jablonsky no. 148.

Plate VII: Fig. 1. *Arundo goepperti* (Münster) Heer, no. 189. **Fig. 2.** *Cyclocarya cyclocarpa* (Schlecht.) Knobloch no. 14. **Fig. 3.** *Cyclocarya cyclocarpa* (Schlecht.) Knobloch no. 15. **Fig. 4.** "*Laurus*" *princeps* Heer (Němejc collection). **Fig. 5.** *Platanus neptuni* (Ett.) Bůžek, Holý & Kvaček no. 79. **Fig. 6.** "*Laurus*" *princeps* Heer, no. 10.





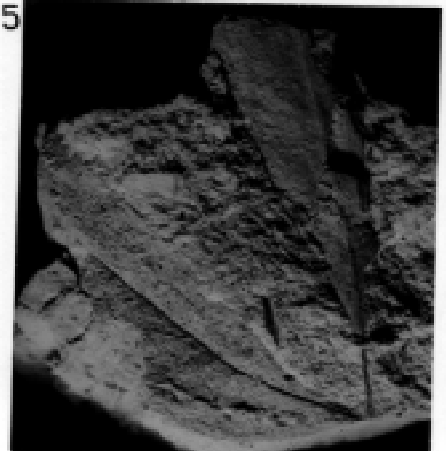
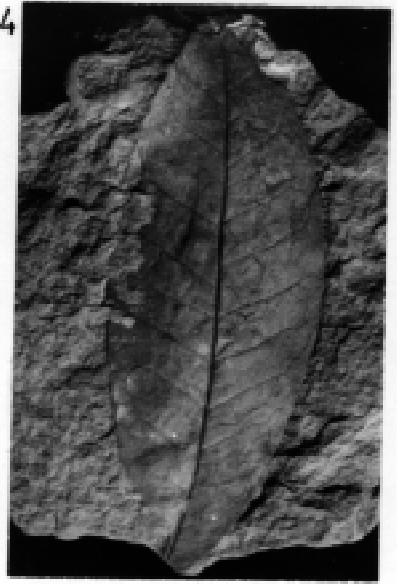
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2



3



Impressions of basal parts of fan-like, palmately compound leaves. In one specimen, the petiole about 24 cm long and 6 cm wide, covered by thorny trichomes 5–6 mm long has been preserved. Leaf lamina is composed of 15–20 segments that are coherent in the basal part and diverge towards the leaf periphery. Venation parallel, composed of fine veins of equal thickness.

Chamaerops helvetica differs from *Sabal* (mostly reported as *Sabal major* (Unger) Heer from the European Tertiary) by small size, smaller number of leaf segments, the kind of obtuse petiole attachment to the lamina (acute in *Sabal*) as well as the thorny surface of the petiole. The fossil record of *Chamaerops* is quite scanty. It is known for example from the type localities Bollingen and Uznach in Switzerland (Heer 1855), and from Engelwies west of Munich (Schweigert 1992), both Early Miocene in age, like Lipovany.

Our material matches well the western Mediterranean *Chamaerops humilis* L., which is a helophile and thermophile element.

Poaceae

Arundo goeppertii (Münster) Heer
Pl. VII: Fig. 1

- 1839 *Culmites Goepperti* — Münster, p. 103, pl. 3, figs. 1–3, pl. 4, figs. 1–2.
1847 *Bambusina sepultum* — Unger, p. 128, pl. 40.
1855 *Arundo (Donax) Goepperti* — Heer, p. 62, pl. 22, f. 3, pl. 23.
1866 *Arundo Goepperti* Heer — Ettingshausen, p. 19, pl. 4, figs. 1, 3–4.
1955 *Arundo goepperti* (Münst.) Heer — Andreánszky, p. 182.

Material: 189

Impression of the inner part of the axis, 2.5–3 cm wide. Nodes are 9 cm apart, 0.4–0.5 cm in thickness. In the internodes there is no structure visible, only near one node a faint parallel venation.

Ribbon-shaped leaf fossils with parallel venation are more commonly reported in the literature, but have not been found at Lipovany. The genus *Arundo* (Poaceae) has been recorded more often in Eocene to Pliocene deposits of Eurasia.

Species list of the flora of Lipovany

This species	Němejc & Knobloch (1973)
<i>Plagiothecium</i> sp.	
<i>Asplenium</i> sp.	
<i>Woodwardia muensteriana</i>	
<i>Pinus saturni</i>	
<i>Tetraclinis salicornioides</i>	
<i>Magnolia diana</i>	
<i>Magnolia</i> cf. <i>mirabilis</i>	
<i>Magnolia</i> sp.	cf. <i>Nyssa</i> sp.
<i>Litsea ipolytarnocensis</i>	
" <i>Persea</i> " <i>speciosa</i>	
" <i>Laurus</i> " <i>primigenia</i>	<i>Laurus</i> sp. ("Laurus" cf. <i>primigenia</i>)
" <i>Laurus</i> " <i>princeps</i>	<i>Laurophyllum</i> cf. <i>princeps</i>
	<i>Laurophyllum</i> cf. <i>braunii</i>
	<i>Laurophyllum</i> cf. <i>lalages</i>
	<i>Laurophyllum</i> cf. <i>heerii</i>

Laurophyllum pseudoprinceps

Laurophyllum cf.

acutimontanum

Laurophyllum cf. *reussii*

Daphnogene polymorpha

Daphnogene spectabile

Daphnogene polymorpha

f. *bilinica*

Daphnogene bilinica

Daphnogene polymorpha

f. *bilinica*

Daphnogene cinnamomifolia

Platanus neptuni

Myrica cf. *sagoriana*

Cyclocarya cyclocarpa

Cyclocarya cyclocarpa

Engelhardia orsbergensis

Engelhardia detecta

Engelhardia macroptera

Engelhardia macroptera

Engelhardia sp.

Caesalpinia norica

Cassia berenices

aff. *Andromeda* sp.

cf. *Cassia* sp.

"*Robinia*" *regelii*

Leguminosites sp.

Ceanothus sp. vel. *Ziziphus* sp.

Acer angustilobum

Sapindus falcifolius

cf. *Iceaciniophyllum* sp.

Ternstroemites sp.

cf. *Diospyros brachysepala* *Diospyros brachysepala*

Pungiphyllum cruciatum

"*Celastrus*" *oxyphyllum*

Dicotyllophyllum sp.

aff. *Quercus neriifolia*

? "*Notelaea*" sp.

Calamus noszkyi

Calamus noszkyi

Chamaerops helvetica

Arundo goeppertii

Floristic relations

The species list of Lipovany (see table) includes less species than that of Ipolytarnóc (Hably 1985, p. 123) but with rare exceptions shares most taxa. Some discrepancies may occur due to different nomenclature and splitting of form species. This similarity was already stressed by Němejc & Knobloch (1973) and Hably (1985). In both sites the paleosubtropical element is well represented prevails while the modern Arcto-Tertiary genera, like *Acer*, and *Cyclocarya*, make only a fragment of the flora. Both sites represent a single characteristic complex. Mai (1995) treats it within the trans-European Paratethys bio (zoo) province in his floristic complex Ipolytarnóc–Luzern, dated by mammals in the MN3 zone. The characteristics, he gives, fits well our data with some corrections: lack of evergreen Fagaceae, lack of the Mastixiaceae and Symlocaceae. These anomalies may arise due to substratum conditions, because the mentioned groups usually avoid volcanic environments. It is noteworthy, that several species are shared across the bioprovince boundary. In the North Bohemian Basin (also MN3 zone but Atlantic-Boreal bioprovince) the following taxa occur infrequently: *Woodwardia muensteriana*, *Tetraclinis salicornioides*, *Laurophyllum pseudoprinceps*, *Platanus neptuni*, *Engelhardia macroptera*, *E. orsbergensis*, *Mahonia*, *Pungiphyllum*. Due

to northerly position and different vegetation (mostly riparian forests), deciduous elements prevail there. The flora of the Sokolov Basin at the base of the Cypris shale is also a good match (Bůžek et al. 1996). *Tetraclinis*, *Platanus neptuni*, *Engelhardia* and *Leguminosae* are well represented there. This complex is dated by mammals to the zone MN4. The floristic characteristics of both mammal zones may not contribute much to their differentiation. But warming trends within the Eggenburgian surely culminate at the level of the Lipovany-Ipolytarnóc floras. Logically, the late mastixioid floras of the Eichelskopf-Wiese complex together with Schwandorf etc. Mai (1995) would be contemporary. They also correspond to a climatic optimum, but show few floristic links.

Vegetation and paleoecology

The absence of swampy and river-side elements in the fossiliferous strata at Lipovany suggests that the vegetation of close surroundings thrived on mesic habitats. Deciduous broad-leaved trees are represented by the fossil species of *Cyclocarya*, *Engelhardia*, *Cassia* and other *Leguminosae* and *Pungiphyllum* (?), as can be assumed from their thin leaf lamina. Laurophyllous element and *Platanus neptuni* are well represented. In the number of specimens *Engelhardia orsbergensis* and *Cassia berenices* dominate in the assemblage. Hably (1985) also found in the sites near Ipolytarnóc always one or a few species dominating in individual assemblages. She explains this apparent anomaly by distinct differentiation of communities within the ancient plant cover. The sedimentary setting, i.e. volcanic tuffitic deposits, suggest very limited transport and hence limited mixing of source vegetation as reflected in the fossil assemblage. But we hesitate to use absolute numbers of leaf fossils for assessing abundance, i.e. the frequency of trees. The Lipovany assemblage unites all three communities as defined by Hably (1985) and stresses common aspects of vegetation within the Ipolytarnóc/Lipovany complex. Palms, *Engelhardia*, Lauraceae, *Platanus neptuni*, *Tetraclinis* are components of Nothophyllous Broad-leaved Evergreen Forest, as it is known from some Late Mastixioid floras of Central Europe. The volcanic environment, especially soils, may have influenced the composition in that evergreen Fagaceae were lacking in contrast to sites in lignite basins. (In the Oligocene volcanic floras of the České Středohoří Mts. the Fagaceae are also exceptional). The vegetation of the Lipovany site was apparently a multi storeyed forest with higher canopy occupied by *Platanus neptuni*, *Engelhardia* and admixture of *Pinus*, lower tree storey with the Lauraceae, *Tetraclinis*, *Magnolia*, *Cyclocarya* and *Cassia* and the shrub storey with palms and Lauraceae, together (?) with enigmatic *Pungiphyllum*, Theaceae and "*Celastrus*".

The forest was dense, not allowing herb undergrowth to develop. We may visualize such conditions in humid subtropical zone, such as on Atlantic coasts of the Canary Islands or Florida.

Both the floristic composition and physiognomy of leaves (size, margin) corroborate a humid subtropical climate. Dominating species are all thermophilous, but certainly not

tropical. Leaf size varies between notophyllous and microphyllous classes. In spite of the limited number of species, we can estimate that entire-margined taxa make up more than 50 %. We agree with Hably (1985) in characterizing climatic conditions before the end of the Early Miocene as corresponding to the subtropical rain forest zone. In contrast to her estimates, we expect a mean annual temperature of less than 20° (Hably 1985), which would mean tropical-paratropical conditions. More realistic values would vary between 15–18°, with the mean of the coldest month above 1°. Similar climatic conditions are estimated for the zone Ng VI of the floristic stratigraphy of Mai, which also corresponds with the Ipolytarnóc/Lipovany complex in age (Mai 1995).

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