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# Early Miocene flora of the South Slovakian basin

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ABSTRACT. The studied fossil flora comes from two adjacent localities of Egerian and Eggenburgian age, in the South Slovakian basin. Extrazonal vegetation and riparian forest taxa with a high percentage of herbs prevail in the material from the old clay pit in Slovenské Ďarmoty (Egerian). Palaeoclimatic conditions are estimated to be humid and subtropical. This is based on the mixture of evergreen and deciduous broad-leaved trees and other plants of moist habitats with the frequent occurence of Pinaceae. Mainly Lauraceae are present at the Biely Vrch locality, which is Eggenburgian in age.

KEY WORDS: macroflora, sporomorphs, Egerian, Eggenburgian, South Slovakian basin

## INTRODUCTION

From the geological point of view, the studied area belongs to the Ipeľ depression and its tectonic and palaeogeographical evolution has been studied by Vass et al. (1979), Vass (1983), and Šutovská-Holcová et al. (1993). Sediments with plant macrofossils and palynomorphs come from the outcrop in the old clay pit, which is situated in the south-west margin of Slovenské Ďarmoty village, and also from the outcrop at the Biely Vrch locality (Fig. 1).

Two global transgressive-regression cycles and sea level changes occurred during the Egerian (Kováč 2000). The Opatová Member encloses the sedimentary sequence of the Lučenec Formation in the Ipeľ depression as a part of South Slovakian basin (Vass 2002). It is a regressive member of the Egerian younger global sea level changing cycles (25.5–22.0 Ma). This member represents a prograding delta, which is documented by the typical litho- and


**Fig. 1.** Location of the investigated area

biofacies. The Opatova Member is the latest Egerian in age. Its age determination was based on calcareous nannoplankton between the NN1/NN2 zones (Šutovská-Holcová et al. 1993).

The Eggenburgian shallow water transgressive sediments from the Biely Vrch are called the Ďarmoty Member. Vass (1983) interpreted this sediment as Eggenburgian denudation relicts forming the so-called Ďarmoty beds. Their typical profile is situated on the southern slope of the Biely Vrch , where conglomerates, gravels, sands, sandstones and calcareous clays alternate. These layers contain very poor fauna with only the moluscs *Ostrea*, *Anomia*, *Panopea*, *Pecten*, *Cardium*, and burrow fillings by Visa (Seneš 1952, Gabčo 1959). Faunistic association does not allow specification of the biostratigraphical characterization of the studied sediments. Estimation of their age is supported only by superpositional relationship evidence (Vass 1983).

Since all Eggenburgian sediments in the southern part of the Ipeľ depression are characterized by transgressive coastal facies, this was sufficient reason to rank them to the Burdigalian (Seneš 1952).

## MATERIAL AND METHODS

The material including fossil plants was gathered during several field trips in the South Slovakian basin about 10 years ago and is housed at the Department of Geology and Palaeontology, Faculty of Sciences, Comenius University in Bratislava, Slovak Republic.

The leaf taxa were determined only on the basis of leaf morphology, it was impossible to make a cuticle analysis due to bad preservation of leaf impressions.

Sporomorphs from the same material were prepared for analysis in the laboratory at the Department of Geology and Palaeontology, Faculty of Sciences, Comenius University using the Erdtman´s acetolysis method (Erdtman 1943). Sporomorphs were very badly preserved in the coarse-grained sediments.

## MACROREMAINS

In the localities Biely Vrch and Slovenské Ďarmoty there have been found fossil plant remains of the Pinaceae from conifers, and Aceraceae, Betulaceae, Caesalpiniaceae, Cyperaceae, Fabaceae, Fagaceae, Juglandaceae, Lauraceae, Myricaceae, Platanaceae, and Sapotaceae from angiosperms. Most of them are preserved as leaf impressions, one specimen is a shoot of *Pinus*. In addition, one seed of *Pinus* sp. and one legume (*Leguminocarpon* sp.) were found. Some leaf impressions, very poorly preserved, could be determined only to the genus (*Cassia* sp., *Dicotylophyllum* sp. (*Magnolia*?), *Laurus* sp., and *Cyperacites* sp. from the monocotyledons). A short description of the exactly determined and illustrated taxa is given.

### ***Pinus saturni*** Ung.

Pl. 1, fig. 1

1847 *Pinus saturni* Ung., Unger, p. 16, pls 4, 5.

Localities. Biely Vrch, Slovenské Ďarmoty.

Several joined needles, fascicles probably with three needles, fragmentary preserved, their maximum length is 7 cm and width 0.5–0.7 mm.

### ***Daphnogene polymorpha*** (A. Br.) Ett. forma ***bilinica*** (Ung.) Sitár & Kvaček

Pl. 1, fig. 6

1997 *Daphnogene polymorpha* (A. Braun) Ettingshausen forma *bilinica* (Unger) stat. n., Sitár & Kvaček, p. 270, pl. 3, figs 3–8.

Localities. Biely Vrch, Slovenské Ďarmoty.

Leaves lanceolate, narrowed towards the base and apex. The size ranged from 4–10 cm in length and 1.5–3.0 cm in width. Midrib mostly straight, basal veins slightly thinner, arising from the base at various levels. Veins subparallel to the margin on about two thirds of the leaf length, where they loop with secondaries or merge with the higher order venation.

### ***Bumelia minor*** Ung.

Pl. 1, fig. 4

1850 *Pyrus minor* Ung., Unger, p. 183, pl. 59, figs 16–24.
1866 *Bumelia minor* Ung., Unger, p. 25, pl. 6, figs 11–19.

Locality. Slovenské Ďarmoty.

Ovate leaf with rounded slightly emarginated apex, narrowed to the petiole. Leaf is 2.5 cm long and 1.6 cm wide. Margin is entire. The midrib is straight, secondary veins bent towards the top and forked.

### ***Leguminocarpon*** sp.

Pl. 1, fig. 5

L o c a l i t y. Slovenské Ďarmoty.

Impression of the almost whole legume is 3 cm long and 1.2 cm wide. Similar fossil remains Heer (1859) includ to the genus *Acacia*.

### ***Caesalpinia macrophylla*** Heer

1859 *Caesalpinia macrophylla* Heer, p.110, pl. 137, figs 11, 11b.

L o c a l i t y. Slovenské Ďarmoty.

Leaflet elliptic, slightly emarginate at the apex, 3.5 cm long and 1.5 cm wide.

### ***Trigonobalanopsis rhamnoides*** (Rossm.) Kvaček & Walther

Pl. 1, fig. 8

1840 *Phyllites rhamnoides* Rossmässler, pl. 8, figs 30, 31.
1989 *Trigonobalanopsis rhamnoides* (Rossmässler), comb. nova, Kvaček & Walther, p. 222–224, fig. 4: g, h, i, j, l.

L o c a l i t y. Slovenské Ďarmoty.

Leaves are elliptic, acuminate, 6–7 cm long and 3 cm wide. Margin is entire. Venation brochidodromous, midrib straight or slightly curved, secondary veins originating at angles of 45 to 70º.

### ***Acer tricuspidatum*** Bronn

Pl. 2, fig. 5

1838 *Acer tricuspidatum* Bronn, pl. 353, fig. 10a, b.

L o c a l i t y. Biely Vrch.

Leaves are trilobite of various size, with rounded to slightly cordate, sometimes cuneate or truncate base. Lobes of unequal size, the central one usually is the largest. Margin fine, sometimes double, three, or even five time serrate. Primary veins divergent from the base at angles of 30 to 75º, secondary veins originate at angles of 20 to 70º; they are alternate or opposite.

### cf. ***Platanus neptuni*** (Ett.) Bůžek, Holý & Kvaček

Pl. 1, fig. 3, Pl. 2, fig. 3

1866 *Sparganium neptuni* Ettings., Ettingshausen, p. 31, pl. 7, figs 9–5, 17, 18.
1967 *Platanus neptuni* (Ettingshausen) comb. nov., Bůžek, Holý & Kvaček, p. 205, pl. 1, figs 1–6, pl. 2, figs 1–4.

L o c a l i t i e s. Biely Vrch, Slovenské Ďarmoty.

Leaves are up to 10 cm long and 2 cm wide, with cuneate base and acuminate apex. Secondary veins are subopposite, looping at the margin. Leaf margin toothed.

### ***Alnus*** sp.

Pl. 1, fig. 9

L o c a l i t y. Slovenské Ďarmoty.

The upper part of the leaf is 6 cm wide. Midrib stout, straight, the secondary veins slightly curved, upward originating at angles from 40 to 50º. Venation is craspedodromous. Tertiary veins distinct, thin and almost at right angles, slightly curved and sometimes forked.

### ***Myrica longifolia*** Ung.

Pl. 2, fig. 2

1850 *Myrica longifolia* Ung., Unger, p. 159, pl. 27, fig. 2, pl. 28, fig. 1.

L o c a l i t y. Slovenské Ďarmoty.

Leaves are linear, 10–12 cm long and 0.4–0.7 cm wide with a toothed margin. Midrib is straight or slightly curved , secondaries not visible.

### ***Myrica*** sp.

Pl. 1, fig. 7, Pl. 2, fig. 4.

L o c a l i t y. Slovenské Ďarmoty.

Leaves narrow oblong, narrowed to the apex and cuneate base. Primary vein is straight, almost indistinct, secondaries also indistinct.

### ***Comptonia acutiloba*** Brongn.

Pl. 2, fig. 1

1828 *Comptonia acutiloba* Brongn. Brongniart, pp. 141, 143, 209.

L o c a l i t y. Biely Vrch.

Leaves are with lobes, smaller towards the apex. Primary vein straight, distinct, secondary veins forming a wide angle (often 70–90º).

### ***Engelhardia orsbergensis*** (Wessel & Weber) Jähnichen, Mai & Walther

1977 *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, Mai & Walther, comb. n., Jähnichen, Mai & Walther, p. 323, pl. 9, fig. 4.

L o c a l i t i e s. Biely Vrch, Slovenské Ďarmoty.

Leaves narrow elliptic or lorate, 2.4–6.0 cm long and 0.4–1.4 cm wide, with anasymmetric base; margin sparsely, finely toothed. Venation brochidodromous to semicraspedodromous, intersecondaries present.

## SPOROMORPHS

### ***Baculatisporites primarius*** (Wolff 1934) Pflug & Thomson in Thomson & Pflug 1953

1934 *Sporites primarius* n. sp., Wolff, p. 66, pl. 5, fig. 8.

1953 *Baculatisporites primarius* (Wolff 1934) n. comb., Pflug & Thomson in Thomson & Pflug, p. 56, pl. 2, fig. 51

Spores trilete, amb (equatorial outline), almost circular, diameter 40–70 µm. Exine less than 1 µm thick. Laesura arms straight, thin, reaching half of the spore radius. Surface is baculate, baculae of various shape and size, densely spaced, sharp or flat on their tops.

B o t a n i c a l a f f i n i t y. Osmundaceae. Most similar to the recent genus *Osmunda*.

P a l a e o f l o r i s t i c a l e l e m e n t. Palaeotropical/arctotertiary.

### ***Corrugatisporites corruvallatus*** (Krutzsch 1967) Nagy 1985

Pl. 3, fig 12

1967 *Trilites corruvallatus* n. fsp., Krutzsch, p. 74, pl. 19, figs 1–19.

1985 *Corrugatisporites corruvallatus* (Krutzsch 1967) comb.nov., Nagy, p. 89, pl. 21, figs 13, 14.

Spores trilete, amb triangular with straight or slightly concave sides and slightly rounded apices. Size 42 µm. Exine up to 3 µm thick. Leasura arms reaching 4/5 of the length of the spore radius, bordered by thickenings of the exine with an undulate outer margin.

B o t a n i c a l a f f i n i t y. Lygodiaceae. Similar to the recent genus *Lygodium*.

P a l a e o f l o r i s t i c a l e l e m e n t. Palaeotropical (subtropical).

### ***Corrugatisporites microvallatus*** (Krutzsch 1967) Nagy 1985

Pl. 3, fig 11

1967 *Trilites mircrovallatus* n. fsp., Krutzsch, p. 76, pl. 20, figs 1–11.

1985 *Corrugatisporites microvallatus* (Krutzsch 1967) comb. nov., Nagy, p. 91, pl. 22, figs 12–14.

Spores trilete, amb triangular with straight or concave sides and truncate to lobate apices. Dimension 28–30µm. Exine 2.0–2.5 µm thick, distinctly thicker on the apices. Laesura arms reaching 3/4 to 4/5 of the length of the spore radius, bordered by narrow exine thickenings with slightly undulate outer margins. Spore surface covered with short rugulae, more distinctly developed on the distal face.

B o t a n i c a l a f f i n i t y. Lygodiaceae. Similar to the recent genus *Lygodium*.

P a l a e o f l o r i s t i c a l e l e m e n t. Palaeotropical (subtropical).

### ***Corrugatisporites multivallatus*** (Pflug in Thomson & Pflug 1953) Planderová 1990

Pl. 3, figs 5, 6

1953 *Corrugatisporites solidus* Potonié subsp. *multivallatus* n. subsp. Pflug, Thomson & Pflug, p. 55, pl. 2, figs 37, 38.

1990 *Corrugatisporites multivallatus* (Pflug) n. comb., Planderová, p. 32, pl. 20, figs 10–13.

Spores trilete, amb triangular with slightly concave sides and flat rounded apices. Dimension 38–44 µm. Exine (without sculpture elements) about 2 µm thick, somewhat thicker on the apices. Laesura arms reaching 4/5 length of the spore radius, bordered by thicker exine, psilate on the surface and undulate outer margin. Proximal surface rugulate. On the distal face rugulate sculpture with bigger elements 3.5–4.0 µm high.

B o t a n i c a l a f f i n i t y. Lygodiaceae. Similar to the recent genus *Lygodium*.

P a l a e o f l o r i s t i c a l e l e m e n t. Palaeotropical (subtropical).

### ***Cryptogrammasporis magnoides*** (Krutzsch 1963) Skawińska in Ziembińska-Tworzydło et al. 1994

1963 *Stereisporites (Stereigranisporis) magnoides* n. fsp., Krutzsch, p. 90, pl. 26, figs 1–12.

1994 *Cryptogrammasporis magnoides* (Krutzsch 1963) Skawińska comb. nov., Ziembińska-Tworzydło et al., p. 10, pl. 2, fig. 1.

Spores trilete, amb triangular to circular. Dimension more than 37 µm. Exine about 2 µm thick. Laesura arms 2/3 to 1/2 of the length of the spore radius. Proximal surface psilate, or bearing loosely spaced granula or small verrucae, about 1 µm in diameter. Distal face is verrucate. Verrucae densely spaced, 3–6 µm in diameter, forming pseudoreticulate pattern.

B o t a n i c a l  a f f i n i t y. Pteridaceae. Similar to the recent genus *Cryptogramma*.

P a l a e o f l o r i s t i c a l  e l e m e n t. Arctotertiary.

**_Leiotriletes adriennis_** (Potonié & Gelletich 1933) Krutzsch 1959

1933 *Punctati-sporites adriennis* sp. Potonié & Gelletich, p. 521, pl. 2, figs 14, 15.
1959 *Leiotriletes adriennis* (Potonié & Gelletich 1933) comb.n. subfsp. adriennis, Krutzsch, p. 57.

Spores trilete, amb triangular with convex sides and rounded apices. Dimension 50–60 µm. Exine about 1 µm thick, psilate or slightly punctate. Laesura arms with pointed ends, reaching about 2/3 of the length of the spore radius. Spores often in equatorial view.

B o t a n i c a l  a f f i n i t y. Lygodiaceae. Similar to the recent genus *Lygodium*.

P a l a e o f l o r i s t i c a l  e l e m e n t. Palaeotropical.

cf. **_Leiotriletes maxoides_** Krutzsch 1962

Pl. 3, fig. 13

1962 *Leiotriletes maxoides maxoides* n. sp. et subsp., Krutzsch, p. 18, pl. 2, figs 1–5.

Spores trilete, amb triangular to rounded-triangular with wide rounded apices. Dimension 56–80 µm (72 µm). Exine up to 1.5 µm thick, at the apices slightly thicker, surface psilate. Laesura arms straight, divided at their ends, reaching 2/3 of the lenght of spore radius. Labrum distinct.

B o t a n i c a l  a f f i n i t y. Lygodiaceae. Similar to the recent genus *Lygodium*.

P a l a e o f l o r i s t i c a l  e l e m e n t. Palaeotropical.

**_Leiotriletes_** sp.

Pl. 3, fig.10

Spores trilete, amb rounded-triangular. Exine thin, at the apices slightly thicker. Surface of the spore is psilate. Laesura arms straight, divided at their ends.

B o t a n i c a l  a f f i n i t y. Lygodiaceae.

P a l a e o f l o r i s t i c a l  e l e m e n t. Palaeotropical.

**_Verrucatosporites alienus_** (Potonié 1931) Thomson & Pflug 1953

Pl. 3, figs 4, 8, 9

1931a *Sporonites alienus* n. sp., Potonié, p. 556, fig. 1.
1953 *Verrucatosporites alienus* (Potonié 1931) n. comb., Thomson & Pflug, p. 60, pl. 3, figs 47–48.

Spores monolete with bean-shaped amb, equatorial diameter 50–60 µm, polar axis 35–40 µm long. Surface covered with loosely but regularly spaced rounded verrucae, 4–6 µm in diameter and 3–4 µm high.

B o t a n i c a l  a f f i n i t y. Davalliaceae. Similar to the recent genus *Davallia*.

P a l a e o f l o r i s t i c a l  e l e m e n t. Palaeotropical (subtropical).

**_Verrucatosporites bockwitzensis_** Krutzsch 1967

1967 *Verrucatosporites bockwitzensis* n. fsp., Krutzsch, p. 190, pl. 71, figs 1, 2.

A monolete spore, size 50–55 µm surface verrucate. Verrucae 6–8 µm in diameter, flat and mostly concentrically arranged.

B o t a n i c a l  a f f i n i t y. According to Planderová (1990) perhaps Polypodiaceae.

P a l a e o f l o r i s t i c a l  e l e m e n t. Palaeotropical.

**_Verrucatosporites_** sp.

Pl. 3, fig. 7

A monolete spore, size 51 µm, surface verrucate. Verrucae in comparison with *Verrucatiosporites alienus* smaller in size, more dense spaced and regularly distributed on the surface.

B o t a n i c a l  a f f i n i t y. Polypodiaceae.

P a l a e o f l o r i s t i c a l  e l e m e n t. ?Palaeotropical.

**_Abiespollenites latisaccatus_** (Trevisan 1967) Krutzsch 1971 ex Ziembińska-Tworzydło 1974

Pl. 3, fig. 17

1967 *Pityosporites latisaccatus latisaccatus* n. fsp. et n. subf. sp., Trevisan, p. 23, pl. 12, fig.4.

1971 *Abiespollenites latisaccatus* (Trevisan 1967) n. comb. [=*Abies latisaccatus* (Trevisan 1967)], Krutzsch, p. 88, pl. 16, figs 1–5.

1974 Abiespollenites latisaccatus (Trevisan 1967) Krutzsch 1971 ex Ziembińska-Tworzydło, p. 348, pl. 8, fig. 2, pl. 10, fig 1.

Pollen grains bisaccate, 90–125 µm long. In equatorial view outline of pollen grains uniform, corpus outline trapezoid with considerably convex proximal face, 84–100 µm long and 53–73 µm high. Sacci are semicircular in outline, obliquely attached to the corpus, 47–64 µm in diameter and 40–45 µm high.

Botanical affinity. Pinaceae.

Palaeofloristical element. Arctotertiary.

**_Cathayapollis millayi_** (Sivak 1976) Ziembińska-Tworzydło 2002

1976 *Cathaya millayi* sp. nov., Sivak, p. 278, pl. 17, figs 1–6, pl. 18, figs 1–7.

2002 *Cathayapollis millayi* (Sivak 1976) comb. nov., Ziembińska-Tworzydło in Stuchlik et al., p. 18, pl. 17, figs 1–8.

Pollen grains bisaccate, 50–76 µm long. In polar view amb not uniform, with a deep indentation, symmetric to the longer equatorial axis. On the proximal face exine infrabaculate up to 4 µm thick. Sacci are nearly circular in outline, 33–48 µm broad, considerably wider than the breadth of corpus, distally attached close by each other. Sacci surface is smooth, exine infrastructure alveolate.

Botanical affinity. Pinaceae, similar to the recent *Cathaya*.

Palaeofloristical element. Arctotertiary (warm-temperate).

**_Cathayapollis potoniei_** (Sivak 1976) Ziembińska-Tworzydło 2002

1976 *Cathaya potoniei* sp. nov., Sivak, p. 272, pl. 13, figs 1–10.

2002 *Cathayapollis potoniei* (Sivak 1976) comb. nov., Ziembińska-Tworzydło in Stuchlik et al., p. 17, pl. 15, figs 1–10.

Pollen grains bisaccate, 50–60 µm long. In polar view amb uniform, corpus ellipsoidal to broadly ellipsoidal. On the proximal face exine nearly psilate, infrabaculate, 1.5 µm thick. Sacci semicircular in outline, distally attached close by each other. Surface of sacci smooth, exine infrastructure alveolate. Alveolae at the marginal part closed, densely spaced up to 2 µm in diameter.

Botanical affinity. Pinaceae, similar to the recent *Cathaya*.

Palaeofloristical element. Arctotertiary (warm-temperate).

**_Cathayapollis pulaensis_** (Nagy 1985) Ziembińska-Tworzydło 2002

1985`*Cathaya pulaensis* n. sp., Nagy, p. 134, pl. 65, figs 1–3.

2002`*Cathayapollis pulaensis* (Nagy 1985) comb. nov., Ziembińska-Tworzydło in Stuchlik et al., p. 18, pl. 18, figs 1–10.

Pollen grains bisaccate, 40–65 µm long, sinusoidal amb in polar view with shallow indentations, symmetric to the longer equatorial axis, corpus ellipsoidal to nearly circular. On the proximal face exine infrabaculate up to 3 µm. Sacci nearly circular in outline 30–40 µm broad, distinctly overlapping the corpus, distally atttached close by each other. Alveolae at the marginal part small, densely spaced up to 2 µm in diameter, muri thin; in deeper part somewhat bigger, distinct and closed, at the attachment area radially arranged, muri thick.

Botanical affinity. Pinaceae, similar to the recent *Cathaya*.

Palaeofloristical element. Arctotertiary (warm-temperate).

**_Cedripites miocaenicus_** Krutzsch 1971

1971 *Cedripites miocaenicus* n. sp., Krutzsch, p. 120, pl. 29, figs 1–8, text-fig. 8/38, fig. 6/38.

Pollen grains bisaccate, 50–80 µm long. In equatorial view outline nearly uniform, corpus ellipsoidal 50–72 µm long and 40–50 µm high, with strongly convex proximal face. Proximal surface rough, exine 2.5 µm thick, infrabaculate. Sacci obliquely orientate to the corpus. Surface of sacci smooth, exine infrastructure alveolate, alveolae of irregular shape. Muri about 1 µm thick.

Botanical affinity. Pinaceae, similar to the recent *Cedrus*.

Palaeofloristical element. Arctotertiary (warm-temperate).

### ***Piceapollis tobolicus*** (Panova 1966) Krutzsch 1971

1966 *Picea tobolica* n. sp., Panova, p. 220, pl. 105, fig. 5.

1971 *Piceapollis tobolicus* (Panova 1966) n. comb., Krutzsch, p. 104, pl. 22, figs 1–3.

Pollen grains bisaccate, 120–176 µm long. In polar view amb uniform, ellipsoidal, corpus ellipsioidal, 70–160 µm long and 52–84 µm broad. In equatorial view outline of pollen grain nearly uniform, corpus ellipsoidal, 90–100 µm high. Proximal surface nearly smooth, exine infrabaculate. Sacci semicircular in outline, 90–108 µm in diameter and 50–65 µm high. Surface of sacci smooth, exine infrastructure alveolate. Alveolae at the marginal part of saccus smaller, irregularly polygonal, not always closed, densely spaced.

Botanical affinity. Pinaceae, similar to the recent *Picea*.

Palaeofloristical element. Arctotertiary.

### ***Pinuspollenites cedrisacciformis*** (Krutzsch 1971 ex Konzalová in Knobloch et al. 1996) Ważyńska & Grabowska 2002

1971 *Pityosporites cedrisacciformis* n. sp. (=*Pinus cedrisacciformis* n. sp.), Krutzsch, p. 56, pl. 4, figs 9–15.

1996 *Pityosporites cedrisacciformis* (Krutzsch 1971), Konzalova ex Knobloch et al., p. 161.

2002 *Pinuspollenites cedrisacciformis* (Krutzsch 1971 ex Konzalová in Knobloch et al. 1996) comb. n., Ważyńska & Grabowska in Stuchlik et al. p. 28, pl. 36, figs 5, 6.

Pollen grains bisaccate, 77–80 µm long. In equatorial view outline of pollen grains nearly uniform, corpus ellipsoidal 67–70 µm long and 55–60 µm high. Sacci semicircular or more than semicircular in outline, 45 µm in diameter. The attachment line strongly arcuate, axis 40–43 µm long. Surface of sacci smooth, exine infrastructure alveolate. Alveolae at the marginal part small, in deeper part five- to sixangular, bigger, up to 5 µm in diameter. Muri straight or slightly undulate.

Botanical affinity. Pinaceae, similar to the recent *Pinus*.

Palaeofloristical element. Arctotertiary.

### ***Pinuspollenites labdacus*** (Potonié 1931) Raatz 1937 ex Potonié 1958

Pl. 3, fig. 18

1931a *Pollenites labdacus* n. sp., Potonié, p. 3, fig. 32.

1937 *Pinus-pollenites labdacus* (Potonié 1931), Raatz, p. 16.

1958 *Pinuspollenites (*al. *Pollenites) labdacus* (Potonié 1931) Raatz 1937 ex Potonié, p. 62.

Pollen grains bisaccate, 60–84 µm long. In polar view amb tripartite with distinct sacci. Corpus in outline ellipsoidal, rarely more circular, 42–60 µm long and 34–48 µm broad. Surface of sacci smooth, exine infrastructure alveolate. Alveolar layer 4–5 µm thick. Alveolae at the marginal part small, irregular polygonal, densely spaced, in deeper part 2.0–3.5 µm, closed.

Botanical affinity. Pinaceae, similar to the recent *Pinus.*

Palaeofloristical element. Arctotertiary.

### ***Zonalapollenites gracilis*** Krutzsch 1971 ex Konzalová et al. 1993

Pl. 3, fig. 14

1971 *Zonalapollenites gracilis* n. sp. (=*Tsuga gracilis* n. sp.), Krutzsch, p. 142, pl. 38, figs 1–15.

1993 *Zonalapollenites gracilis* Krutzsch, Konzalová et al., pl. 15, fig 3.

Monosaccate pollen grains in polar view circular in outline, diameter 65–80 µm, in lateral view flattened with concave distal face. In the equatorial area 4–5 µm collar, somewhat overlapping the distal side, built of ectexine elements. Ectexine on the proximal face and the area of equator loosely connected with the endexine. Proximal surface covered with verrucae, of irregular shape. Surface of verrucae is smooth.

Botanical affinity. Pinaceae smilar to the recent *Tsuga*.

Palaeofloristical element. Arctotertiary.

### ***Zonalapollenites igniculus*** (Potonié 1931) Thomson & Pflug 1953

1931 *Sporonites igniculus* n. sp., Potonié, p. 556, fig. 2.

1953 *Zonalapollenites igniculus* (Potonié 1931) n. comb., Thomson & Pflug, p. 66, pl. 4, fig. 75.

Pollen grains monosaccate, in polar view circular in outline, diameter 49–51 µm, in lateral view flattened with distinctly concave distal face. In the equatorial area exists a distinct 10–12 µm broad collar, considerable overlapping the body, built of ectexine elements. Surface of the proximal face covered with irregular, hollow verrucae, on the distal face the verrucae very small.

B o t a n i c a l   a f f i n i t y. Pinaceae, similar to the recent *Tsuga*.

P a l a e o f l o r i s t i c a l   e l e m e n t. Arctotertiary.

**_Zonalapollenites spinosus_** (Doktorowicz-Hrebnicka 1964) Ziembińska-Tworzydło 1974

Pl. 3, fig. 15

1964 *Tsuga diversifolia*-type Rudolph forma *spinosa,* Doktorowicz-Hrebnicka, p. 38, pl. 9, fig. 39.

1974 *Zonalapollenites spinosus* (Doktorowicz-Hrebnicka 1964) comb. n., Ziembińska-Tworzydło, p. 353, 354, pl. 12, fig. 1.

Pollen grains monosaccate, in polar view circular in outline, diameter 90–105 µm, in lateral view ellipsoidal. In the equatorial area exists a distinct collar, up to 15 µm broad, built of ectexine elements; surface of these processes covered with loosely spaced, 0.5–1.0 µm long microspinules. Ectexine on the proximal face covered with irregularly shaped, mostly solid verrucae, 2–4 µm in diameter, on the distal face verrucae smaller.

B o t a n i c a l   a f f i n i t y. Pinaceae, similar to the recent *Tsuga*.

P a l a e o f l o r i s t i c a l   e l e m e n t. Arctotertiary.

**_Zonalapollenites verrucatus_** Krutzsch 1971 ex Ziembińska-Tworzydło 1974

Pl. 3, fig. 16

1971 *Zonalapollenites verrucatus* n. sp. (=*Tsuga verrucata* n. sp.), Krutzsch, p. 144, pl. 39, figs 1–10.

1974 *Zonalapollenites verrucatus* Krutzsch, Ziembińska-Tworzydło, p. 353, pl. 12, fig. 4.

Pollen grains monosaccate, in polar view circular in outline, diameter 60–70 µm, in lateral view ellipsoidal. In the equatorial area exist a 4–5 µm broad collar, somewhat overlapping the distal face, built of ectexine elements. Proximal face covered with irregularly shaped, solid verrucae, up to 2 µm in diameter, on the distal face verrucae of regular shape.

B o t a n i c a l   a f f i n i t y. Pinaceae, similar to the recent *Tsuga*.

P a l a e o f l o r i s t i c a l   e l e m e n t. Arctotertiary.

**_Inaperturopollenites concedipites_** (Wodehouse 1933) Krutzsch 1971

1933 *Cunninghamia concedipites* sp. nov., Wodehouse, p. 495, fig. 19.

1971 *Inaperturopollenites concedipites* (Wodehouse 1933) n. comb., Krutzsch, p. 204, pl. 65, figs 1–33.

In equatorial and polar view outline of pollen grains circular, 25–38 µm in diameter. On the distal face in the centre of the leptoma a small papilla. Pollen grain split deeply, with the papilla visible on the bottom of the split. Surface of ectexine densely microgranulate.

B o t a n i c a l   a f f i n i t y. Cupressaceae, similar to the recent *Taxodium* and *Glyptostrobus*.

P a l a e o f l o r i s t i c a l   e l e m e n t. Palaeotropical/Arctotertiary (subtropical to warm-temperate).

**_Sciadopityspollenites quintus_** Krutzsch 1971 ex Ziembińska-Tworzydło 1974

1971 *Sciadopityspollenites quintus* n. sp. (=*Sciadopitys quinta* n. sp.); Krutzsch, p. 180, pl. 55, figs 1–16.

1974 *Sciadopityspollenites quintus* Krutzsch 1971, Ziembińska-Tworzydło, p. 356, pl. 13, fig. 6.

Pollen grains circular in outline, diameter 42 µm, with an elongate leptoma in form of a concavity with very thin exine. Surface of exine covered with loosely spaced, flat, hollow, verrucae of various shape and size, 2–3 µm in diameter. Surface of verrucae, and exine between them, finely granulate.

B o t a n i c a l   a f f i n i t y. Taxodiaceae, similar to the recent *Sciadopitys*.

P a l a e o f l o r i s t i c a l   e l e m e n t. Arctotertiary (warm-temperate).

**_Graminidites_** cf. **_gramineoides_** (Meyer 1956) Krutzsch 1970

1956 *Monoporopollenites gramineoides* n. gen. n. sp., Meyer, p. 111, pl. 128, fig. 29.

1970 *Graminidites graminoides* (Meyer 1956) n. comb., Krutzsch, p. 15.

Monoporate pollen grains of irregular round shape with one pore with a small annulus. Size is up to 25 µm in diameter. Surface of exine is densely granulate.

Botanical affinity. Poaceae.

Palaeofloristical element. Arctotertiary.

**_Monocolpopollenites tranquillus_** (Potonié 1934) Thomson & Pflug 1953

1934 *Pollenites tranquillus* n. sp., Potonié, p. 51, pl. 2, figs 3,8.

1953 *Monocolpopollenites tranquillus* (Potonié 1934) n. comb., Thomson & Pflug, p. 62, pl. 4, figs 24–37, 39–47.

Pollen grains monocolpate with thin wall, 25–35 µm long. Surface of exine finely granulate to scabrate.

Botanical affinity. Arecaceae.

Palaeofloristical element. Palaeotropical.

**_Myricipites myricoides_** (Kremp 1949) Nagy 1969

1949 *Pollenites myricoides* n. sp., Kremp, p. 64, 65, pl. 6, fig 63.

1969 *Myricipites myricoides* (Kremp 1949) n. comb., Nagy p. 245, pl. 54, figs 11, 13, 14.

Pollen grains triporate 25–28 µm in diameter, with a prominent atrium, small annulus and labrum. Exine is granulate, with many dark folds.

Botanical affinity. Myricaceae.

Palaeofloristical element. Palaeotropical.

**_Alnipollenites verus_** (Potonié 1931) ex Potonié 1934

1931c *Pollenites verus* n. sp., Potonié, p. 332, pl. 2, fig. 40.

1934 *Alnipollenites verus* Potonié, p. 58–59, pl. 2, figs 13, 17, 18, 25, 26, pl. 6, fig 28.

Pollen grains 4–6 porate with typical vestibulum and structure of pore apparatus. Size 20–32 µm. Garland-arranged folds of the granulate exine extend from pore to pore.

Botanical affinity. Betulaceae, similar to the recent *Alnus*.

Palaeofloristical element. Arctotertiary.

**_Ilexpollenites margaritatus_** (Potonié 1931) Raatz 1937 ex Potonié 1960

1931c *Pollenites margaritatus* n. sp., Potonié, p. 328, pl. 1, figs 32–33.

1960 *Ilexpollenites margaritatus* (Potonié 1931) Raatz 1937, Potonié, p. 99.

Pollen grains tricolporate, elliptical or round outline in equatorial view, 24–35 µm in diameter. Exine 2–3 µm thick, surface clavate. Clavae mostly 1–2 µm thick. Ornamental elements are various in a length, usually longest at the poles, occasionally scarce in the meridional area.

Botanical affinity. Aquifoliaceae, similar to the recent *Ilex.*

Palaeofloristic element. Palaeotropical.

**_Periporopollenites stigmosus_** (Potonié 1931) Pflug & Thomson in Thomson & Pflug 1953

1931c *Pollenites stigmosus* n. sp., Potonié, p. 322, pl. 2, fig. 1.

1953 *Periporopollenites stigmosus* (Potonie) n. comb., Thomson & Pflug, p. 111, pl. 15, fig. 58.

1960 *Liquidambarpollenites stigmosus* (Potonié 1931) Raatz 1937, Potonié p. 134, pl. 8, fig. 187.

Pollen grains polyporate, diameter 30–35 µm, with large pores (4–5 µm in diameter), exine granulate.

Botanical affinity. Altingiaceae, similar to the recent L*iquidambar*.

Palaeofloristical element. Arctotertiary (warm-temperate).

**_Pterocaryapollenites stellatus_** (Potonié 1931) Thiergart 1937

1931b *Pollenites stellatus* n. sp., Potonié, p. 28, pl. 2, fig. 47b.

1937 *Pterocaryapollenites stellatus* (Potonié 1931) n. comb., Thiergart, p. 311, pl. 34, fig. 19.

Pollen grains six-porate, outline in polar view of hexagonal shape, pores in the equator, provided with a larger or smaller annulus. Species of variable size from 23–42 µm.

B o t a n i c a l a f f i n i t y. Juglandaceae, similar to the recent *Pterocarya*.

P a l a e o f l o r i s t i c a l e l e m e n t. Arctotertiary.

***Intratriporopollenites insculptus***
Mai 1961

1961 *Intratriporopollenites insculptus* n. sp., Mai, p. 64, pl. 10, figs 6–7.

Pollen grains triporate, 40 µm in diameter. Outline convex triangular with strongly developed annulus. Exine microreticulate or granulate-reticulate.

B o t a n i c a l a f f i n i t y. Malvaceae. *Craigia* sp. (according to Kvaček et al. 2002)

P a l a e o f l o r i s t i c a l e l e m e n t. Arctotertiary (warm-temperate).

## RESULTS

Marine regression during the Late Egerian period allowed the origin of a deltaic environment with a typically well diversified transitional terrestrial-brackish environment, within a subtropical and humid climate. Hygrophilous macroflora was represented by the *Cyperites*, *Alnus*, *Myrica*, and the mesophytic elements by Lauraceae, Fabales (*Leguminosites*), Platanaceae, more thermophilous *Trigonobalanopsis rhamnoides*, which is most characteristic of the "Younger Mastixioid" assemblages (Meller et al. 1999). *Pinus* was predominantly present. The occurrence of particular taxa in the both investigated localities is shown in Tables 1, 2.

The extrazonal vegetation (*Abies*, *Cedrus*, *Picea*, *Tsuga*), preferred the higher relief and temperate climatic conditions. Different morphological species of *Cathaya* (*Cathayapollis millayi*, *C. potoniei*, *C. pulaensis*) were found. Spores are represented by Osmundaceae (*Baculatisporites primarius*), Schizaeaceae (*Leiotriletes maxoides*, *Corrugatisporites corruvallatus*, and *Leiotriletes adriennis*), Pteridaceae (*Cryptogrammasporis magnoides*), Polypodiaceae (*Verrucatosporites alienus*, *V. favus*); Angiospermae by *Pterocarya*, *Liquidambar*, *Juglans*, Poaceae, Palmae (*Monocolpopollenites tranquillus*), and the riparian forest by *Craigia*, *Alnus* and *Myrica*.

Sporomorphs from the sediments of Eggenburgian age occurred very rarely. They were considerably mechanically broken, and their exine was also demaged under oxidation influence. The composition of the macrofloral assemblage is very similar to the Egerian one, but is considerably poorer. This is consistent with the lithological type of sediment and the dynamic conditions present during their origin in the transgression period.

**Table 1.** Occurrence of plant macroremains in the investigated localities of South Slovakian basin

| Taxa | Slovenské Ďarmoty | Biely Vrch |
|---|---|---|
| *Pinus saturni* Ung. | + | + |
| *Pinus* sp. (seed) | + | - |
| *Laurus* sp. | + | + |
| *Daphnogene polymorpha* forma *bilinica* (Ung.) Sitár & Kvaček | + | + |
| *Bumelia minor* Ung. | + | - |
| *Caesalpinia macrophylla* Heer | + | - |
| *Cassia* sp. | - | + |
| *Trigonobalanopsis rhamnoides* (Rossm.) Kvaček & Walther | + | - |
| *Acer tricuspidatum* Bronn | - | + |
| cf. *Platanus neptuni* (Ett.) Bůžek, Holý & Kvaček | + | + |
| *Alnus* sp. | + | - |
| *Myrica longifolia* Ung. | + | - |
| *Myrica* sp. | + | - |
| *Comptonia acutiloba* Brongn. | - | + |
| *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, Mai & Walther | + | + |
| *Dicotylophyllum* sp. | + | - |
| *Cyperites* sp. | + | - |

**Table 2**. Occurrence of sporomorphs in the investigated localities of South Slovakian basin. Occurrence: * – rare, ** – common, *** – abundant, **** – very abundant

| Taxa | Slovenské Ďarmoty | Biely Vrch |
|---|---|---|
| *Baculatisporites primarius* (Wolff 1934) Pflug & Thomson in Thomson & Pflug 1953 | * | |
| *Corrugatisporites corruvallatus* (Krutzsch 1967) Nagy 1985 | * | |
| *Corrugatisporites microvallatus* (Krutzsch 1967) Nagy 1985 | * | |
| *Corrugatisporites multivallatus* (Pflug in Thomson & Pflug 1953) Planderová 1990 | * | |
| *Cryptogrammasporis magnoides* (Krutzsch 1963) Skawińska 1994 | * | |
| *Leiotriletes adriennis* (Potonié & Gelletich 1933) Krutzsch 1959 | * | |
| cf. *Leiotriletes maxoides* Krutzsch 1962 | * | |
| *Polypodiaceoisporites* sp. | * | |
| *Verrucatosporites alienus* (Potonié 1931) Thomson & Pflug 1953 | * | |
| *Verrucatosporites bockwitzensis* Krutzsch 1967 | * | |
| *Abiespollenites latisaccatus* (Trevisan 1967) Krutzsch 1971 ex Ziembińska-Tworzydło 1974 | ** | |
| *Cathayapollis millayi* (Sivak 1976) Ziembińska-Tworzydło 2002 | ** | |
| *Cathayapollis potoniei* (Sivak 1976) Ziembińska-Tworzydło 2002 | *** | |
| *Cathayapollis pulaensis* (Nagy 1985) Ziembińska-Tworzydło 2002 | * | |
| *Cedripites miocaenicus* Krutzsch 1971 | ** | |
| *Inaperturopollenites concedipites* (Wodehouse 1933) Krutzsch 1971 | * | |
| *Piceapollis tobollicus* (Panova 1966) Krutzsch 1971 | ** | |
| *Pinuspollenites cedrisacciformis* (Krutzsch 1971 ex Konzalová in Knobloch et al. 1996) Ważyńska & Grabowska 2002 | * | |
| *Pinuspollenites labdacus* (Potonié 1931) Raatz 1937 ex Potonié 1958 | **** | ** |
| *Sciadopityspollenites quintus* Krutzsch 1971 ex Ziembińska-Tworzydło 1974 | ** | |
| *Zonalapollenites gracilis* Krutzsch 1971 ex Konzalová et al. 1993 | * | |
| *Zonalapollenites igniculus* (Potonié 1931) Thomson & Pflug 1953 | ** | |
| *Zonalapollenites spinosus* (Doktorowicz-Hrebnicka1964) Ziembińska-Tworzydło 1974 | * | |
| *Zonalapollenites verrucatus* Krutzsch 1971 ex Ziembińska-Tworzydło 1974 | * | |
| *Alnipollenites verus* Potonié 1931 ex Potonié 1960 | * | |
| *Ilexpollenites margaritatus* (Potonié 1931) Raatz1937 ex Potonié 1960 | * | |
| *Intratriporopollenites insculptus* Mai 1961 | * | |
| *Myricipites myricoides* (Kremp 1949) Nagy 1969 | ** | |
| *Periporopollenites stigmosus* (Potonié1931) Pflug & Thomson in Thomson & Pflug | * | |
| *Pterocaryapollenites stellatus* (Potonié 1931) Thiergart 1937 | * | |
| *Graminidites* sp. | * | |
| *Monocolpopollenites tranquillus* (Potonié 1934) Thomson & Pflug 1953 | * | |

## DISCUSSION

The Egerian fossil flora, known from the Opatova beds (borehole ČO1), situated near the Opatovská Nová Ves village, west of Slovenské Ďarmoty, has been described for the first time by Němejc (1960, 1967) from the two time intervals (at the depths of 42–57 m and 85–24 m). Lauraceae (mainly *Daphnogene*), *Myrica*, *Andromeda*, and *Nyssa* prevailed at these two levels. This corresponds with detailed data revised from this borehole (Šutovská-Holcová et al. 1993). Similar subtropical flora type with prevailing lauroids was found in older sediments of the early Egerian age not far from Linz in Austria (Kovar-Eder 1982).

The composition of vegetation assemblages from Eggenburgian sediments at Biely Vrch is partly comparable with the flora from Lipovany (Sitár & Kvaček 1997) and possibly with Ipolytarnóc flora (Hably 1985).

## CONCLUSION

During the late Egerian regression the deltaic environment was suitable for the preservation of plant fossil remnants. Extrazonal vegetation and riparian forest taxa with a high spore representation are predominantly present in the material, which was studied from the old clay pit in Slovenské Ďarmoty. Based on the mixture of evergreens (Lauraceae), deciduous broad-leafed trees and other plants from moist habitats (*Alnus*, *Myrica*), the palaeoclimatic conditions can be estimated to be humid and subtropical.

More dynamic conditions of environment,

during the Eggenburgian transgression event, were not favourable for the preservation of fossils, especially for sporomorphs. Plant macrofossils, mainly Lauraceae, were still present, but less frequent.

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# PLATES

Plate 1

1. *Pinus saturni* Ung., × 0.7, Slovenské Ďarmoty
2. *Cyperites* sp., × 2, Slovenské Ďarmoty
3. cf. *Platanus neptuni* (Ett.) Bůžek, Holý & Kvaček. × 1.2, Slovenské Ďarmoty
4. *Bumelia minor* Ung., × 2, Slovenské Ďarmoty
5. *Leguminocarpon* sp., × 2, Slovenské Ďarmoty
6. *Daphnogene polymorpha* f. *bilinica* (Ung.) Sitár & Kvaček, × 0.9, Biely Vrh
7. *Myrica* sp., × 0.9, Slovenské Ďarmoty
8. *Trigonobalanopsis rhamnoides* (Rossm.) Kvaček & Walther, × 0.9, Biely Vrch
9. *Alnus* sp., × 0.9, Slovenské Ďarmoty

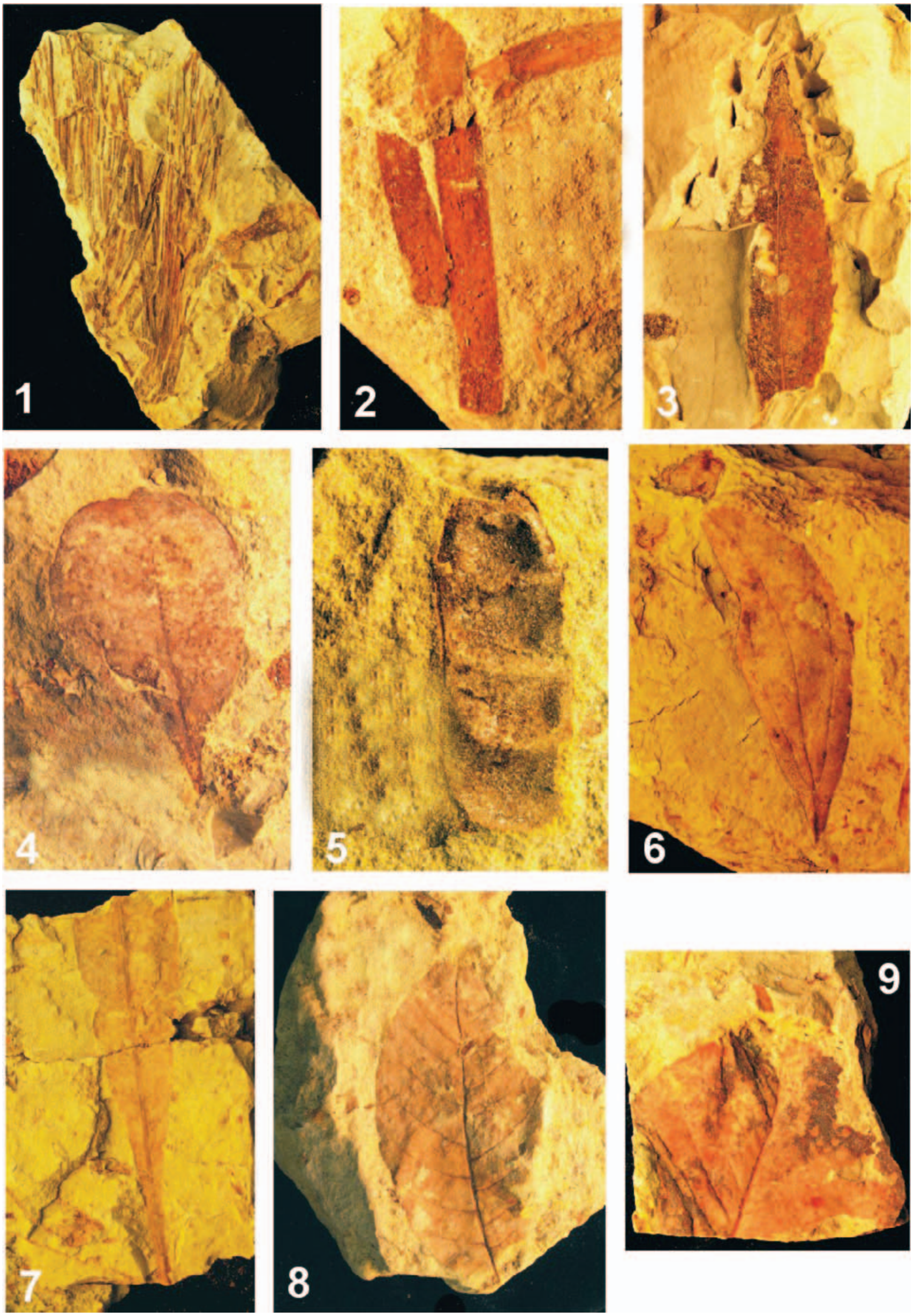
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Plate 2

1. *Comptonia acutiloba* Brongn., × 2, Biely Vrch
2. *Myrica longifolia* Ung., × 1.5, Slovenské Ďarmoty
3. cf. *Platanus neptuni* (Ett.) Bůžek, Holý & Kvaček, × 2, Slovenské Ďarmoty
4. *Myrica* sp., × 2.5, Slovenské Ďarmoty
5. *Acer tricuspidatum* Bronn., × 1.2, Biely Vrch

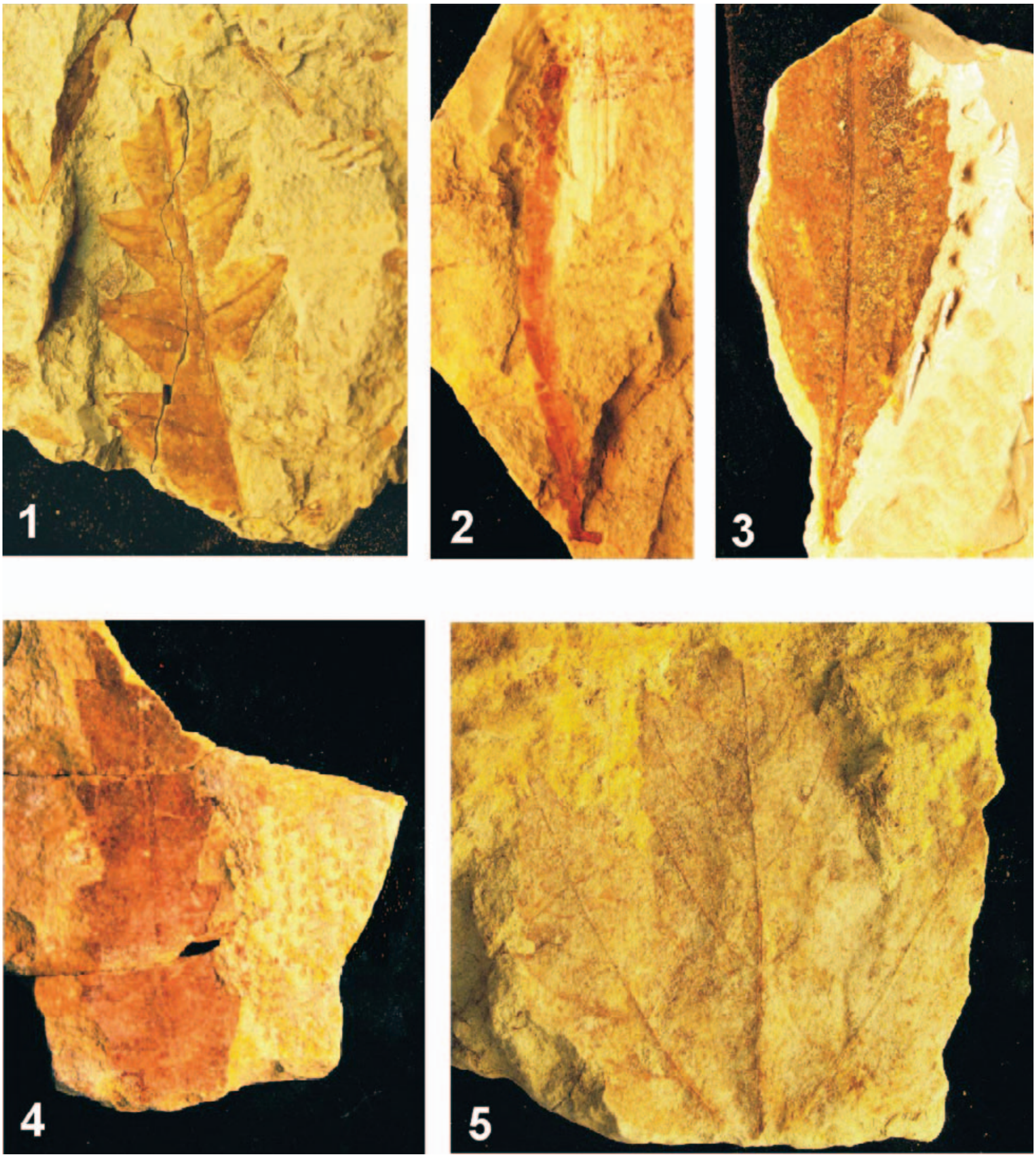
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Plate 3

1–3. Algae

4, 8, 9. *Verrucatosporites alienus* (Potonié 1931) Thomson & Pflug 1953

7. *Verrucatosporites* sp.

10. *Leiotriletes* sp.

5, 6. *Corrugatisporites multivallatus* (Pflug in Thomson & Pflug 1953) Planderová 1990

11. *Corrugatisporites microvallatus* (Krutzsch 1967) Nagy 1985

12. *Corrugatisporites corruvallatus* Krutzsch 1967 Nagy 1985

13. cf. *Leiotrilets maxoides* Krutzsch 1962, size 72 µm

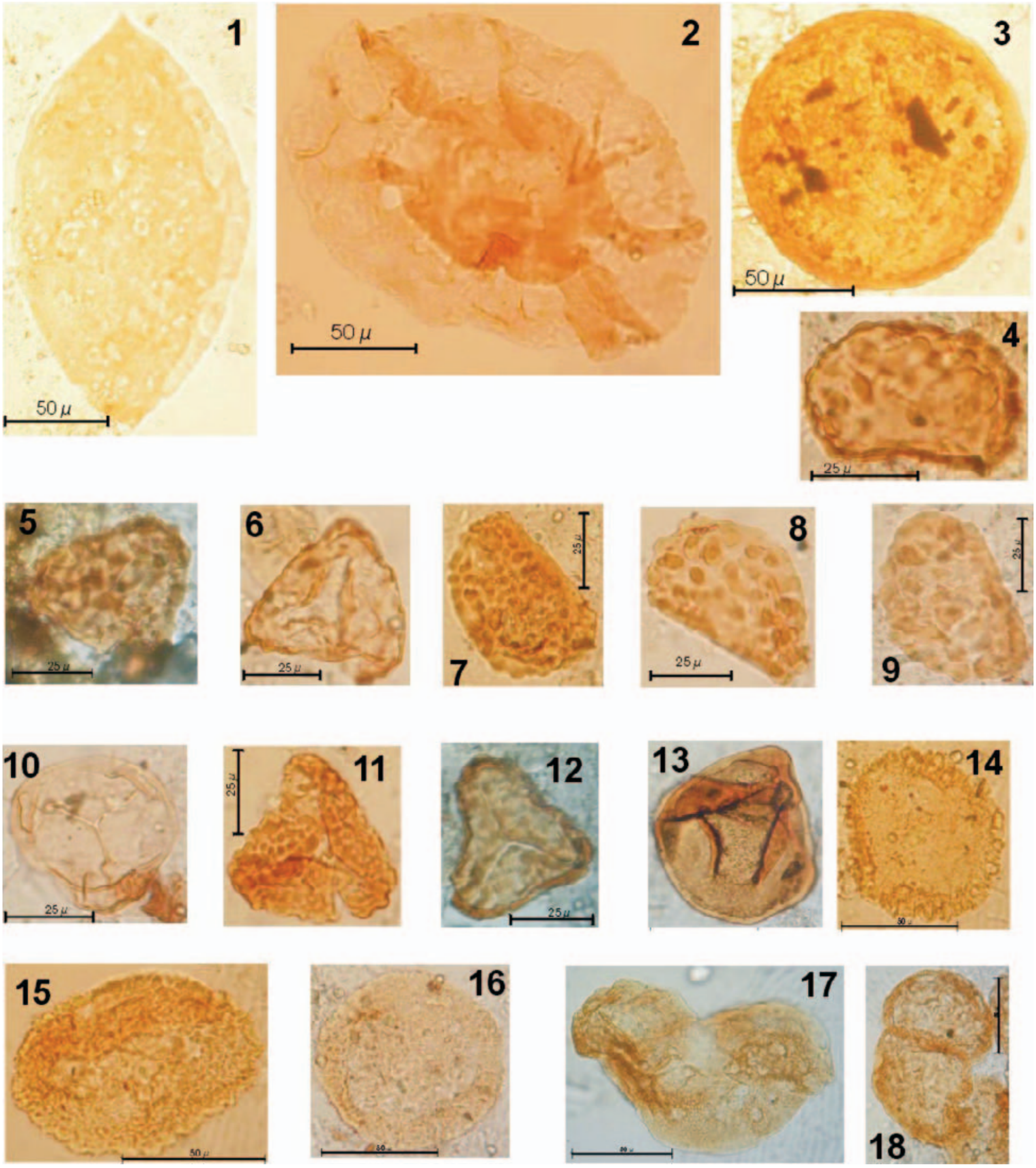
14. *Zonalapollenites gracilis* Krutzsch 1971 ex Konzalová et al. 1993

17. *Abiespollenites latisaccatus* (Trevisan 1967) Krutzsch 1971 ex Ziembińska-Tworzydło 1974

18. *Pinuspollenites labdacus* (Potonié 1931) Raatz1937 ex Potonié 1958

15. *Zonalapollenites spinosus* (Doktorowicz-Hrebnicka1964) Ziembińska-Tworzydło 1974

16. *Zonalapollenites verrucatus* Krutzsch 1971 ex Ziembińska-Tworzydło 1974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