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Plant assemblages of the drill cores from the Neogene Ruja lignite deposit near Legnica (Lower Silesia, Poland)

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ABSTRACT. Fossil plant remains (mainly macroremains of leaves and sporomorphs) were investigated from two boreholes of Ruja lignite deposit near Legnica, Lower Silesia, Poland. In the fossil plant assemblages there were found 34 taxa belonging to the families Betulaceae, Blechnaceae, Cercidiphyllaceae, Cupressaceae, Fagaceae, Hydrocharitaceae, Juglandaceae, Malvaceae, Myricaceae, Nyssaceae, Osmundaceae, Poaceae, Salicaceae, Sapindaceae, Ulmaceae, and Zingiberaceae. All assemblages are characterized by dominance of wetland vegetation (swamp and riparian) elements. Floristic composition of all investigated horizons point to their Middle Miocene (Badenian) age and suggest warm temperate climate conditions with mild winters.

KEY WORDS: fossil plant macroremains, sporomorphs, Ruja lignite deposit, wetland vegetation, warm temperate climate, Middle Miocene, Lower Silesia, Poland

INTRODUCTION

In the course of palynological sampling of the cores drilled in 1991 in the area of prospect Ruja lignite deposit near Legnica (Lower Silesia, Poland), abundant accumulations of plant macroremains, compressions and impressions of fossil leaves, have been found. These represent several horizons of different depths. Until now, only a preliminary report on plant macroremains representing this locality were published (Worobiec & Kasiński 2005).

Research was aimed at investigating palaeofloristics and palaeoecology of plant assemblages within each horizon based on plant remains from the Komorniki 97/72 and 97/73 boreholes. This work documents biodiversity of the Neogene flora and vegetation of the lignite deposit "Ruja" near Legnica. On account of the good state of preservation of plant fossils it was possible to carry out an extensive study of leaf macroremains from the boreholes, combined with investigation on accompanying carpological remains and palynological analysis.

The first author (Grzegorz Worobiec) has investigated plant macroremains and edited the manuscript, Elżbieta Worobiec performed palynological analyses while Jacek Kasiński described geological properties of the Ruja lignite deposit.

GEOLOGY

The Ruja deposit, west of Wrocław, Lower Silesia, belongs to the Legnica-Ścinawa lignite resource complex, the largest lignite-bearing area in Poland (Fig. 1). It is located in the southernmost part of this complex. In the southern part of the complex, the Neogene lignite-bearing association occurs above early Palaeozoic metamorphic rocks (micaceous phyllites and shists and their thick weathering crust) of the Fore-Sudetic Block (Kasiński & Piwocki 2005). In the northern part it overlies Mesozoic sediments of the Fore-Sudetic Monocline. Basalt

Fig. 1. Location of the Ruja lignite deposit in Poland

domes and tuphaceous deposits (Jaroń et al. 1978, Saternus 1995) of Oligocene/Miocene age (Birkenmajer 1967) frequently underlay the lignite-bearing association.

The lignite-bearing association infills a widespread system of tectonic depressions related to the Late-Alpine post-Cretaceous tectonic movements. In the southern part it is strongly tectonically disturbed with W-E and N-S dislocations (Oberc & Dyjor 1969) which cut the crystalline basement of the Ruja deposits into some smaller tectonic blocks.

Thickness of the Neogene lignite-bearing association fluctuates between 2 and 207 m due to the morphology of sub-Cenozoic surface. The thickness averages 90 m (Kasiński et al. 1995) and is the thickest in the central part of the deposits, where both the examined cores Komorniki 97/72 and Komorniki 97/73 (Fig. 2) were bored. The lowermost part of the lignite-bearing association is represented by the upper part of the Rawicz Formation, Early Miocene (i.e. the Spremberg Formation/Lübbenau Beds in Germany), consisting of clayey-silty-sandy sediments with clay and silt predomination, sporadically with the addition of coal dust. Small bodies of quartz sand/gravel are more scarce. Also thin intercalations of white kaoline clay with rich coalified plant detritus and fine branches locally occur. In the examined cores, sediments of the Rawicz Formation probably occur only in the lowermost part of the borehole 97/73.

The Ścinawa Formation, Early Miocene/Middle Miocene (i.e. the Brieske Formation in Germany) represents the upper part of the lignite-bearing association. In the lowermost part, it includes a series of coaly clays, being a sedimentary equivalent of the 3rd Ścinawa lignite seam (Ważyńska 1995). This seam occurs commonly in whole Lower Silesia, but it is lacking within the Ruja Depression. A thin bed of clayey/silty sediments, in some cases with sand or plant detritus lies above. The 2nd Lusatia lignite seam (Middle Miocene) builds up the uppermost part of the Ścinawa Formation profile. It is the homogenous lignite seam in the central part of the Ruja Depression that subdivides the area into three or more benches heading towards the basin margins (Dyląg 1995). This seam provides the major lignite resources of the Ruja Deposit.

Silty and sandy sediments lying above, more scarcely clayey ones, represent the Pawłowice Formation of Middle Miocene age (i.e. the Meuro Formation in Germany). This formation includes coalified plant detritus, and – in the uppermost part – some lignite benches corresponding to the 2nd A Lubin lignite seam. Above the 2nd A Lubin seam, in the 97/72 borehole, more than 8 m thick series of fine sand occurs in the uppermost part of this formation. Horizons with very rich leaf floras (also with accumulations of fossil leaf litter) frequently occur in the lower part of this series: most of the plant remains horizons of the 97/72 borehole (KRAM-P: 243/B, 243/C, 243/D, 243/E) and of the 97/73 borehole (KRAM-P: 244/B, 244/C, 244/D) belong to the Pawłowice Formation. In both the examined boreholes, the bottom surface of the Pawłowice Formation is placed respectively at the depth of 117.2 and about 119.0 m, while the top surface – at the depth of 77.0 and 77.1 m; the 2nd A Lubin seam occurs at the depth of 104.5 – 104.6 and 108.6 –110.6 m, respectively.

The uppermost part of the lignite-bearing association is represented by the Poznań Formation of the Middle Miocene/Early Pliocene age (i.e. Rauno Formation in Germany). It is developed in form of silts and clays, and in some cases also silty sands. Thin lignite seam (the 1st Mid-Polish seam or its sedimentary equivalent, Middle Miocene) occurs in the lowermost part of this formation. In both of the examined boreholes, the bottom surface of the Poznań Formation is placed at the depth of 77.0 and 77.1 m, while the top surface – at the depth of 0.5 and 15.5 m; the 1st Mid-Polish seam occurs only in the 97/72 borehole at the

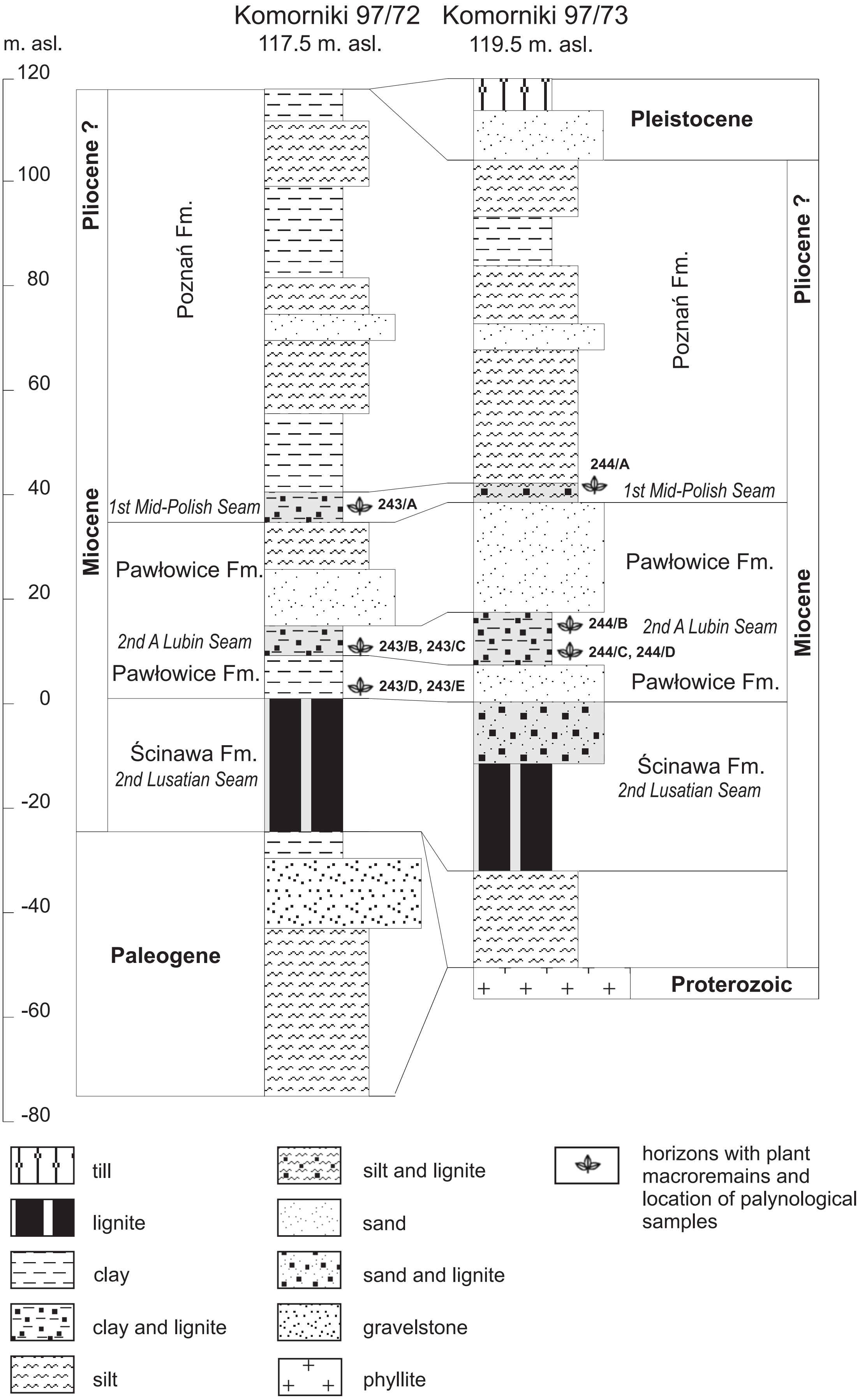

Fig. 2. Geological profiles of boreholes Komorniki 97/72 and Komorniki 97/73 with position of horizons with plant macroremains and palynological samples

depth of 77.5–77.6 m. Two horizons with plant macroremains from both boreholes (KRAM-P: 243/A and 244/A) lie in the lowermost part of Poznań Formation in the horizon equivalent to 1st Mid-Polish seam.

Pleistocene and Holocene deposits cover the Neogene lignite-bearing association with rather thin cover, 0.5–39.0 m thick (15.1 m in average). They are developed in the form of fluviatile and fluvio-glacial deposits with silt intercalations and tills.

Sedimentary development of the Ruja basin was mostly related to some of the stages of basin structural evolution. The lignite-bearing association consists of a few sedimentary megacycles: each began with sudden lowering of the deposition surface affected with tectonic paroxysm. Lower parts of the cycles developed in rather low-energy fluviatile conditions (Jęczmyk et al. 1997) on a large alluvial fan that dewatered northwards. Fine-grained sands and silts originated mostly at this stage and clayey/muddy sediments were deposited at the same time within periodical lakes and oxbows. The leaf flora horizons are mostly related to these sedimentary environments. After gradually infilling of the depression growth of the peat-forming plant assemblages – precursors of lignite – started within the basin area. Floral overgrowth was interrupted with new tectonic paroxysm. Three complete megacycles were recorded within the sedimentary fill of the Ruja basin: the first one related to sedimentation of the Ścinawa Formation, the second – to the lower part of the Pawłowice Formation and the third one – to the upper part of the Pawłowice Formation and lowermost part of the Poznań Formation.

MATERIAL AND METHODS

The study material was collected in 1996 in the course of palynological sampling of the cores from boreholes Komorniki 97/72 and Komorniki 97/73 (boreholes from the Ruja lignite deposit) in the Polish Geological Institute storehouse of borehole cores in Słupeczka near Kłodawa. From the borehole core 97/72 material came from depths 78–79 m, 105–106 m, 106–108 m, 112–115 m, and 117 m while in case of the core 97/73 from depths 77–78 m, 102–105 m, 107–110 m, and 110–111 m. Specimens from borehole 97/72 were marked as KRAM-P 243 (Tab. 1) and specimens from borehole 97/73 were marked as KRAM-P 244 (Tab. 2).

Core fragments with fossil plants were wrapped in newspaper and packed in plastics bags. In the laboratory specimens were additionally dried and finally prepared. From leaf compressions small fragments of carbonized leaf blades were taken for cuticular analysis. All the examined fossil specimens are housed at Władysław Szafer Institute of Botany Polish Academy of Sciences, Kraków. The total number of specimens from all taxa is greater than the total number of fragments of cores with plant remains because on some specimens (fragments of cores) several taxa were preserved. In such cases a specimen number is accompanied by a Roman numeral. In total 280 fossil specimens were investigated.

The state of preservation of the fossil leaves varied from impressions to compressions In case of well preserved compressions cuticular analysis was possible. For cuticular analysis leaf fragments were initially cleaned by immersion in 40% hydrofluoric acid in a closed plastic container under fume hood for 24 hours. Then the HF acid was discarded, and the leaf compression was several times rinsed with water until it was neutralized. Compressions were macerated for up to 3–4 hours (dependent on leaf taxa) using a diluted solution of commercially available bleach "Bielnar" (solution of NaClO, comp. Dilcher 1974). The macerated epidermis was then embedded in glycerine jelly preparation. Altogether 122 slides of leaf epidermis were made.

In a few horizons there have been found abundant accumulations of coalified plant remains in the form of fossil leaf litter (composed of humified shreds of leaf blades and branches of coniferous plants). To isolate determinable plant remains, portions of leaf litter were rinsed in 1 % solution of H_2O_2 (hydrogen peroxide). After a few minutes of maceration, swollen mass of plant remains was moved into large container, rinsed in tap water, and sieved several times through plastic sieves to eliminate remaining H_2O_2 and clay particles. After washing, the mass of plant remains was searched for determinable plant remains with binocular microscope. Most of selected remains were dried, macerated leaf cuticles (*cuticulae dispersae*) were embedded in 42 glycerine jelly preparation.

Drawings of leaves were made using a Carl Zeiss stereomicroscope with *camera lucida* attachment. Macrophotography of the fossil leaves was made using a NIKON Coolpix 995 digital camera. Bright field, dark field and phase contrast microphotography of the fossil leaf epidermis were made using NIKON Eclipse E400 microscope fitted with the NIKON Coolpix 995 digital camera.

Macromorphological descriptions of fossil leaves were based on the nomenclature proposed by Hickey (1979). Features of micromorphological structure were interpreted on the basis of papers by Dilcher (1974) and Wilkinson (1979). The method of measuring the size of micromorphological structures depended on their shape. In case of regular, round or broadly elliptical structures, their diameter was measured, while in quadrangular their length and width. Structures with irregular or variable shape (mainly epidermal cells) and rounded to elliptical stomata had their longest dimension measured (size).

For comparative purposes we used the herbarium at Władysław Szafer Institute of Botany Polish

Academy of Sciences, Kraków (KRAM), reference herbarium at the Department of Palaeobotany, and collections of epidermal preparations from fossil and recent leaves kept at Władysław Szafer Institute of Botany, Kraków, and the Museum of the Earth, Polish Academy of Sciences, Warszawa.

Ten samples from horizons with plant macroremains were palynologically analysed, one from each horizon with an exception of horizon 102–105 m from the borehole Komorniki 97/73 (KRAM-P 244/B) from which two samples were analysed. Material for pollen analysis was prepared by a modification of Erdtman's acetolysis method using HF acid (Faegri & Iversen 1975, Moore et al. 1991).

Table 1. Horizons with plant macroremains in borehole Komorniki 97/72

Depth (m)	Horizon label	Number of specimens	Fossil taxa	Number of taxa	Presence of fossil leaf litter
78–79	KRAM-P 243/A	34	cf. *Byttneriophyllum tiliifolium*, *Glyptostrobus europaeus*, *Glyptostrobus* vel *Sequoia*, *Myrica lignitum*, *Osmunda parschlugiana*, *Phragmites oehningensis*, *Salix hausruckensis*, *S. varians*, *Salix* sp. 1, *Salix* sp., *Sequoia abietina*, cf. *Zingiberoideophyllum liblarense*	12	+
105–106	KRAM-P 243/B	40	*Acer tricuspidatum*, *Alnus julianiformis*, *A. menzelii*, *Byttneriophyllum tiliifolium*, *Cyperacites* sp., Dicotyledones incertae sedis, *Dicotylophyllum* sp. 1, *Glyptostrobus europaeus*, *Glyptostrobus europaeus* - cones, Incertae sedis, cf. *Myrica lignitum*, *Salix hausruckensis*, *Salix* sp., *Woodwardia muensteriana*	13	+
106–108	KRAM-P 243/C	22	*Acer* sp., *Acer* sp. ex gr *Rubra*, *Cyperacites* sp., Dicotyledones incertae sedis, *Dicotylophyllum* sp. 1, Incertae sedis, *Phragmites oehningensis*, *Salix varians*	8	–
112–115	KRAM-P 243/D	55	*Acer* sp., *Acer tricuspidatum*, *Alnus menzelii*, *Byttneriophyllum tiliifolium*, cf. *„Ficus" truncata*, *Ulmus* sp., *Cyperacites* sp., Dicotyledones incertae sedis, *Dicotylophyllum* sp. 4, *Pterocarya paradisiaca*, *„Castanea" kubinyii*, *Ulmus* cf. *ruszovensis*, *Ulmus* sp.	13	–
117	KRAM-P 243/E	leaf litter	*Glyptostrobus europaeus, Osmunda parschlugiana*	2	+

Table 2. Horizons with plant macroremains in borehole Komorniki 97/73

Depth (m)	Horizon label	Number of specimens	Fossil taxa	Number of taxa	Presence of fossil leaf litter
77–78	KRAM-P 244/A	1	*Osmunda parschlugiana*	1	–
102–105	KRAM-P 244/B	74	*Acer tricuspidatum*, *Acer* sp. ex gr *Rubra*, *Acer* sp., *Alnus menzelii*, cf. *A. menzelii*, *Byttneriophyllum tiliifolium,* cf. *Carpinus grandis*, Dicotyledones incertae sedis, cf. *„Ficus" truncata*, *Glyptostrobus europaeus*, *G. europaeus* - twig and cones, *Incertae sedis*, *Myrica lignitum*, cf. *M. lignitum*, *Phragmites oehningensis*, *Populus populina*, cf. *Populus sp.*, *Salix* cf. *kicktonii*, *S. hausruckensis*, *S. varians*, *Salix* sp., *Ulmus pseudopyramidalis*, *Ulmus* sp., *Ulmus* vel *Zelkova*, *Zelkova zelkovifolia*	25	+
107–110	KRAM-P 244/C	44	*Alnus menzelii*, *Byttneriophyllum tiliifolium*, *Cercidiphyllum* (?) *crenatum*, Dicotyledones incertae sedis, *Dicotylophyllum* sp. 2, *Dicotylophyllum* sp. 3, *„Ficus" truncata*, *Glyptostrobus europaeus*, *G. europaeus* – twigs and cone, *Hydrocharitaceae* gen. indet., *Nyssa ornithobroma*, *Salix hausruckensis*, *Salix* sp., *Spirematospermum wetzleri*, *Ulmus* sp., cf. *Varipilicutis liblarensis*, *Zingiberoideophyllum liblarense*	17	+
110–111	KRAM-P 244/D	7	*Byttneriophyllum tiliifolium*, *Byttneriophyllum tiliifolium* vel *„Ficus" truncata*, *Taxodium* vel *Sequoia*	3	–

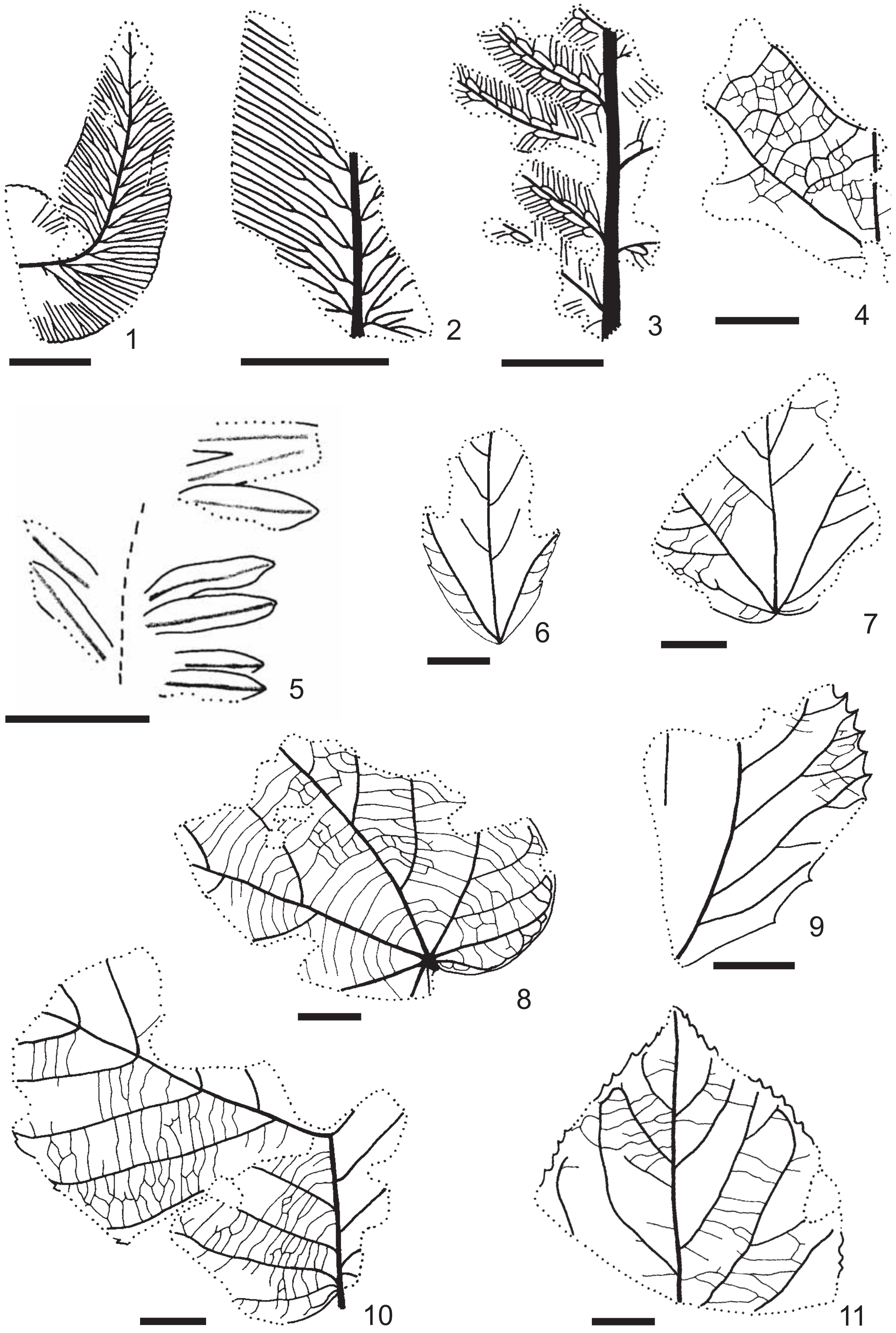

Fig. 3. 1–2 – *Osmunda parschlugiana* (Unger) Andreánszky: **1** – specimen KRAM-P 244/A/1, **2** – specimen KRAM-P 243/A/9; **3** – *Woodwardia muensteriana* (Presl in Sternberg) Kräusel, specimen KRAM-P 243/B/18/III; **4** – cf. *„Ficus” truncata* Heer sensu Bůžek, specimen KRAM-P 243/D/27; **5** – *Sequoia abietina* (Brongniart) Knobloch, specimen KRAM-P 243/A/27; **6** – *Acer tricuspidatum* Bronn sensu Procházka & Bůžek, specimen KRAM-P 244/B/22/I; **7** – *„Ficus” truncata* Heer sensu Bůžek, specimen KRAM-P 244/C/8/I; **8** – *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Z. Kvaček, specimen KRAM-P 244/B/28/I; **9**, **11** – *Populus populina* (Brongniart) Knobloch: **9** – specimen KRAM-P 244/B/6/II, **11** – specimen KRAM-P 244/B/32; **10** – *Alnus menzelii* Raniecka-Bobrowska, specimen KRAM-P 244/C/6. Scale bar – 1 cm

SYSTEMATIC PART

Osmundaceae L.

Osmunda L.

Osmunda parschlugiana (Unger) Andreánszky

Fig. 3: 1, 2; Pl. 1, fig. 1, Pl. 8, figs 1, 2

1847 *Pteris parschlugiana* Unger, p. 122, pl. 36, fig. 6.

1959 *Osmunda parschlugiana* (Unger) Andreánszky, p. 45, Fig. 2, pl. 7, fig. 4.

Material. KRAM-P 243: A/9, A/13, A/19/II, A/22, E/leaf litter; KRAM-P 244: A/1.

Macromorphology. Fragments of pinnae of fern fronds up to 4.0 cm long and 1.4–1.8 cm wide, lorate or very narrow ovate. Leaflets (pinnae) margin serrate, teeth very small, tooth apex rounded, apical side of tooth short, concave or acuminate, basal side of tooth long and acuminate. Midvein considerably thick, straight. Numerous lateral veins are dichotomously forked and terminate in the sinuses between teeth. Lateral veins arranged mostly alternate, curve slightly downward, arising from primary vein at intervals of 0.20–0.35 cm at angles of 40–50°. Basal lateral veins multiply branched, remaining lateral veins first branched near primary vein and second time more distantly. Vein density at margin 12–25 per 1 cm.

Micromorphology. Epidermis composed of irregular-shaped cells, 68.9–147.6 μm in size. Anticlinal cell walls usually Ω-undulate and thick, only cells with trichomes have less undulate walls. Stomata anomocytic, elliptic, wide elliptic, occasionally rounded, 39.4–59.0 μm in size. Outer stomatal ledge aperture wide spindle-shaped or elliptic, 24.5–35.0 μm long and 14.8–24.6 μm wide. Indistinct polar T-shaped cuticular thickness occasionally visible. On the epidermis unicellular, simple (unbranched) trichomes were found, numerous in places, 110–170 μm long with acute apical side. Trichome bases elliptic-rounded, unicellular, 17.2–23.4 in diameter.

Remarks. The specimens described were assigned to *Osmunda parschlugiana* (Unger) Andreánszky. Large leaflets (pinnae) with finely dentate margins are characteristic for this species. The other fossil species, *O. lignitum* (Giebel) Stur, differs strongly in the pinnatifid leaflets. Andreánszky (1959) placed *Pteris parschlugiana* Unger with the genus *Osmunda*.

Osmunda parschlugiana is considered to have been a component of swampy vegetation in the Neogene flora of Central Europe (Mai 1995).

Osmunda parschlugiana is very similar to *Osmunda regalis* L., a component of the contemporary flora of Poland. This fern occurs almost exclusively in areas with mild climate marked with distinct oceanic features. In Poland *Osmunda regalis* is found mainly in the north-western part of the country, mostly in swamp forests. In North America *Osmunda regalis* also grows in swamp forests (Kearney 1901).

Occurrence in the fossil floras of Poland. Early Miocene – Bełchatów (Worobiec 1995, 2003); Miocene – Chroślice (Kräusel 1920), as *Pteris parschlugiana* Unger).

Blechnaceae (C. Presl) Copel.

Woodwardia Smith

Woodwardia muensteriana (Presl in Sternberg) Kräusel

Fig. 3: 3

1838 *Pecopteris muensteriana* Presl in Sternberg, p. 154, pl. 36, fig. 2.

1841 *Woodwardia muensteriana* F. Braun, p. 33.

1921 *Woodwardia muensteriana* (Presl in Sternberg) Kräusel, pp. 366–369, pl. 11, figs 2, 6–8, pl. 12, fig. 4.

Material. KRAM-P 243: B/18/III, B/35/II.

Macromorphology. Fragments of fern frond, once pinnatisect with pinnule 1.5–2.0 cm long and 0.5–0.7 cm wide. Pinnule margin serrate or serrate-crenate, teeth very poorly preserved. Leaf rachis 0.1–0.2 cm thick. Venation dichotomous – reticulate with characteristic areolae near midrib of pinnule. On the areole on both sides of midrib are located elongate sporangia, 1.3–1.7 mm long and 0.6–0.7 mm wide. Pinnules lie at intervals of about 0.5 cm. Midrib of pinnule form the angle of 60–70° with rachis.

Remarks. Characteristic dichotomous – reticulate venation with areolae near midrib of pinnule and pinnatisect frond show that the specimens undoubtedly represent fossil fern of

Woodwardia muensteriana (Presl in Sternberg) Kräusel. Based upon the opinion of Kvaček and Hurník (2000) this species is conspecific with *W. roessneriana* Unger.

In the Palaeogene and Neogene floras *Woodwardia muensteriana* constituted a component of swamp vegetation. The leaves of this species are most similar to those of the contemporary *W. virginica* (L.) SM. that grows in Atlantic North American swamps (Sakala 2000).

Occurrence in the fossil floras of Poland. Middle Miocene – Dobrzyń on the Vistula river (Kownas 1956) and Miocene – Chroślice (Kräusel 1921) as *Woodwardites münsterianus* (Presl in Sternberg) F. Br.

Cupressaceae Rich. ex Bartling

Glyptostrobus Endl.

Glyptostrobus europaeus (Brongniart) Unger

Pl. 1, figs 3, 7, 8, Pl. 8, figs 3–5

1833 *Taxodium europaeum* Brongniart, pp. 168–176, pl. 3, pl. 12.
1850b *Glyptostrobus europaeus* (Brongniart) Unger, pp. 434–435.

Material. KRAM-P 243: A/4, A/26/I, B/13, B/21, B/23, E/leaf litter; KRAM-P 244: B/10/, B/17/III, B/21, B/37/II, B/39/II, C/1/I, C/2/III, C/4, C/5, C/7, C/9/I, C/12/II, C/19/II, C/23, B/5/I, B/18, C/8/IV, C/15.

Macromorphology. Fragmentary shoots, 0.10–0.17 cm wide (commonly 0.13–0.17 cm), bearing dense, adjacent to axis scale-like (cupressoid) needles, 0.17–0.37 cm long and 0.06–0.10 cm wide with commonly acute and hardy ever rounded apex and decurrent base. Occasionally needles are hook-shaped.

Micromorphology. Epidermal cells almost always quadrangular, mostly elongate, occasionally square, 17.2–78.7 μm long and 7.4–24.6 μm wide. Anticlinal cell walls thick, straight, rounded, occasionally undulate (especially short cell walls). Cuticle thick, distinctly granulate, possibly papillae or crystals visible on cuticle (outside or inside cells). The hypodermal cells quadrangular, frequently square, 14.8–66.4 μm long. Hypodermal cell walls distinctly thinner than epidermal. Stomata cyclocytic, surrounded by 4–6 subsidiary cells, elliptic, frequently somewhat deformed, 41.8–66.4 μm long and about 30–40 μm wide. Longer axes of stomata mainly oblique to midvein, stomata arranged in stomatal bands of variable length. Outer stomatal ledge aperture distinctly cutinized, oblongate, 14.8–29.5 μm long and 2.5–7.4 (12.3) μm wide. Polar T-shaped cuticular thickness present, strongly cutinized.

Remarks. Both the morphology of shoots and the structure of stomata corresponds to the fossil species *Glyptostrobus europaeus* (Brongniart) Unger. Cupressoid type of *Sequoia abietina* (Brongniart) Knobloch shoots is macromorphologically similar to the taxon under discussion, but differs in having considerably longer epidermal cells.

Glyptostrobus europaeus along with *Taxodium* Rich. was a dominant component of Neogene swamp forests in Europe (Mai 1995).

Glyptostrobus pensilis (Staunton) K. Koch is a contemporary counterpart of *Glyptostrobus europaeus* in southern China and Vietnam, both being distributed along river banks, often in swampy places, typically occupying small areas (Henry & McIntyre 1926, Hiêp & Vidal 1996).

Occurrence in the fossil floras of Poland. *Glyptostrobus europaeus* is a common component of Neogene floras from Poland. It has been reported from many localities in Miocene floras (see Zalewska 1959, Zastawniak et al. 1996) and from one locality of Early Pliocene age (Ruszów, Baranowska-Zarzycka 1988).

Glyptostrobus europaeus (Brongniart) Unger – cones

Pl. 1, figs 4, 5

Material. KRAM-P 243: B/15, B/16, B/18/I, B/30.

Description. Cones more or less obovoid, strongly compressed, 1.4–1.6 cm long and up to 1.2 cm wide. Cone scales elongated, with triangular apex.

Remarks. Cones typical of *Glyptostrobus europaeus* (Brongniart) Unger.

Glyptostrobus europaeus (Brongniart) Unger vel ***Sequoia abietina*** (Brongniart) Knobloch

Material. KRAM-P 243: A/3/II, A/6/II, A/15.

Remarks. Fragments of cupressoid, coniferous shoots, without cuticular data. It does not seem to be possible to distinguish shoots of *Glyptostrobus europaeus* and *Sequoia abietina* relying exclusively on the basis of their morphology.

Sequoia Endl.

Sequoia abietina (Brongniart) Knobloch

Fig. 3: 5; Pl. 1, fig. 6, Pl. 8, fig. 6, Pl. 9, figs 1, 2

1822 *Phyllites abietina* Brongniart; Cuvier, p. 360, pl. 11, fig. 14.
1855 *Sequoia langsdorfii* (Brongniart) Heer, p. 54, pl. 20, fig. 2, pl. 21, fig. 4.
1964 *Sequoia abietina* (Brongniart) Knobloch, p. 601.

Material. KRAM-P 243: A/5/I, A/7, A/8, A/10, A/11/II, A/12, A/14/II, A/16, A/18, A/19/I, A/23, A/25, A/27.

Macromorphology. Shoots dimorphous. Taxodioid shoots bear flat, entire-margined needles with distinctly marked midvein, up to 1.6 cm long (only fragments of needles) and 0.13–0.28 cm (commonly 0.15–0.20 cm) wide, apex mainly acute, base obtuse or cuneate and decurrent. Needles arranged in one plane on both sides of shoots. Cupressoid shoots bear smaller entire-margined needles, up to 0.35 cm long and 0.6–0.7 cm wide with acute apex and decurrent base. On the top of shoots, apical bud often preserved, up to 0.18 cm long.

Micromorphology. Features of epidermal cells of cupressoid and taxodioid shoots of *Sequoia* from Ruja are similar. Cells of epidermis are almost always rectangular, often very elongate, 73.8–250.0 μm long and 9.8–22.1 μm wide. Cell walls thick or very thick, straight, end walls usually rounded, frequently undulate. Cuticle very thick. Hypodermis consists of rectangular cells, often square, 37.0–147.6 μm long and 17.2–49.2 μm wide. Cell walls of hypodermis usually straight or rounded, occasionally undulate, cell walls thin (considerably thinner than epidermal cells). Stomata monocyclocytic, elliptic to elliptic-elongated, 49.2–71.3 μm long and 34.4–46.7 μm wide. Some differences between the above mentioned morphotypes could be found in the stomatal orientation and network. Taxodioid shoots have wide stomatal bands composed of several stomatal rows, longer axes of these stomata more or less parallel to the midvein of needle. Stomatal bands of cupressoid type are arranged in narrow bands, longer axes of stomata are oblique to midvein. Outer stomatal ledge aperture oblongate (sausage-like), 19.7–34.5 μm long and 2.5–7.4 μm wide surrounded by cuticular crest. Polar T-shaped cuticular thickening always present, very distinct.

Remarks. Fragments of twigs represent *Sequoia abietina* (Brongniart) Knobloch. Detailed macromorphological shoot description of *S. abietina* was included in the monograph of the fossil flora from Gozdnica (Kvaček in: Dyjor et al. 1992), where three morphological types were distinguished: taxodioid, cryptomerioid and cupressoid. In the investigated material only the taxodioid and cupressoid types were found.

A distinction between the fossil taxodioid shoots of *Sequoia* Endl. and macromorphologically similar shoots of *Taxodium* Rich. is the orientation of the longer axes of stomata. They are perpendicular or slightly oblique to the longer axis of a needle in *Taxodium*, while in the taxodioid shoots of *Sequoia abietina* the longer axes of stomata are parallel to the needle axis.

To distinguish the cupressoid shoots of *Sequoia abietina* from the twigs of *Glyptostrobus europaeus* (Brongniart) Unger, Sveshnikova (1963) considered the proportion of length to width in the epidermal cells as a feature distinguishing shoots of *Sequoia* from those of *Glyptostrobus*. In *Sequoia* cell length exceeds its width as much as 7–12 times, while in *Glyptostrobus* epidermal cell length is only 3–4 times greater than its width. Kovar-Eder (1996) confirms the presence of such a difference in case of *Sequoia abietina* from Bilina and Oberdorf. This difference is also noticeable in *S. abietina* and *Glyptostrobus europaeus* from Ruja.

Sequoia abietina occurs in Neogene deposits from Central Europe, and is particularly abundant in the middle part of Neogene (Dyjor et al. 1992). It is accepted that this tree occurred mostly in the last stage of the succession of the coal-forming vegetation (raised bog, facies M, Schneider 1992), where it typically occupied

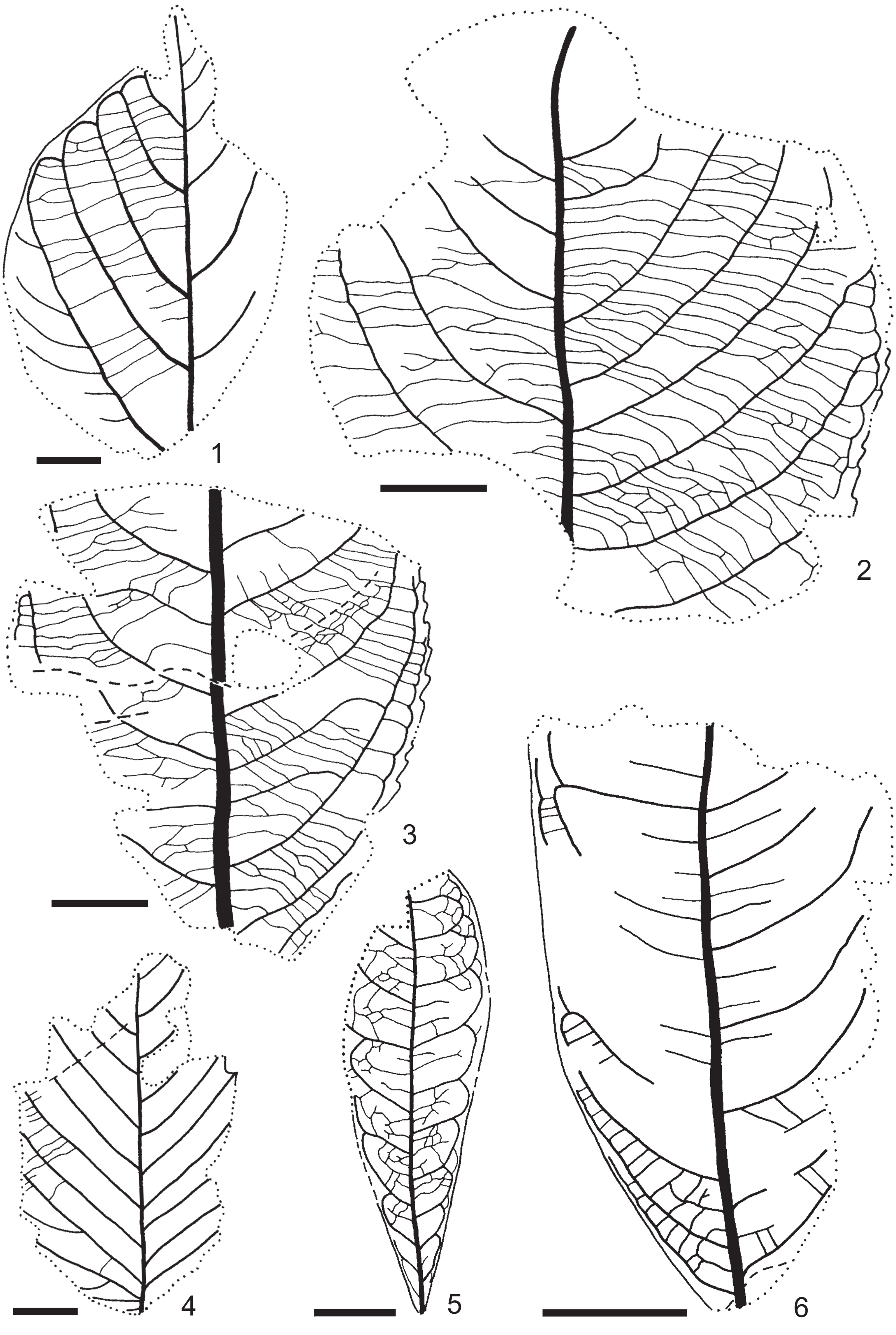

Fig. 4. 1– *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Z. Kvaček, specimen KRAM-P 243/D/41; **2–3** - *Salix hausruckensis* Kovar-Eder: **2** – specimen KRAM-P 243/B/1, **3** – specimen KRAM-P 243/B/34; **4** – cf. *Carpinus grandis* Unger emend. Heer, specimen KRAM-P 244/B/19/II; **5** – *Myrica lignitum* (Unger) Saporta *sensu lato*, specimen KRAM-P 244/B/34/I; **6** – *Salix varians* Goeppert *sensu lato*, specimen KRAM-P 243/A/17. Scale bar – 1 cm

drier places. Fossil remains of *Sequoia* are also found in alluvial sediments (Dyjor et al. 1992) therefore Kovar-Eder et al. (2001) considered it as a prevailing riparian element in the Miocene flora of Oberdorf.

The fossil *Sequoia abietina* is comparable to recent *S. sempervirens* (D. Don) Endl. from western part of North America. This species grows on the slopes of the Coastal Range Mountains in California (Watson 1993).

Occurrence in the fossil floras of Poland. Early Miocene – Turów (Zalewska 1959) and Osieczów (Raniecka-Bobrowska 1962) as *Sequoia langsdorfii* (Brongniart) Heer; Middle Miocene – Rypin (Łańcucka-Środoniowa 1957, as *S. langsdorfii*), Bełchatów (Stuchlik at al. 1990), Wieliczka (Łańcucka-Środoniowa & Zastawniak 1997); Late Miocene – Gozdnica (Dyjor et al. 1992), Bełchatów (Worobiec 2003).

Taxodium dubium (Sternberg) Heer vel ***Sequoia abietina*** (Brongniart) Knobloch

Pl. 1, fig. 2

Material. KRAM-P 244: D/1/II, D/4/I.

Remarks. Specimens macromorphologically similar both to *Taxodium dubium* and *Sequoia abietina*. Cuticular detail are not preserved hence identification remains uncertain.

Dicotyledones

Sapindaceae Jussieu

Acer L.

Acer tricuspidatum Bronn *sensu* Procházka & Bůžek

Fig. 3: 6; Pl. 2, figs 1, 2, 5, Pl. 9, figs 3, 4

1838 *Acer tricuspidatum* Bronn, p. 865, pl. 35, figs 10a, b.
1845 *Acer trilobatum* A. Braun, p. 172.
1975 *Acer tricuspidatum* Bronn sensu novo, Procházka & Bůžek, p. 24, Figs 2, 3, 4d, 5–13, pl. 22, figs 1–7, pl. 23, figs 1–6, pl. 24, figs 1–4.

Material. KRAM-P 243: B/17, B/28, B/29, D/4/I, D/6, D/8/I, D/11/I, D/11/II; KRAM-P 244: B/2, B/13, B/19/I, B/22/I.

Macromorphology. Leaves mostly trilobate. Lobe apex attenuate or acute, leaf base cordate. Leaf margin simple serrate. Teeth relatively large, upwardly curved (hooked). Apical side of teeth acuminate or concave, basal side acuminate, rarely straight, tooth apex rounded or acute. Secondary veins or branches of them terminate in teeth apex. Venation actinodromous, perfect, basal, marginal. Primary vein branched into 3-5-7 branches. Tertiary veins branched, midway between secondary veins forming a characteristic network of interconnected veins. Higher order venation more or less orthogonal reticulate. Areoles well developed, 0.2–0.4 mm in size.

Micromorphology. Adaxial epidermis composed of isodiametric or slightly elongated cells, often quadrangular, with mostly straight walls, 19.7–56.6 μm in size. Abaxial epidermis composed of isodiametric or elongate cells, over the veins strongly elongated, with straight or rounded cell walls, 9.8–34.5 μm in size. Surface of cuticle granular (probably due to presence of epicuticular wax). Leaves hypostomatic. Stomata anomocytic (seemingly paracytic, see Hummel 1983), elliptic, rarely rounded, 14.8–24.6 μm in size. Outer stomatal ledge aperture rather distinct, and of characteristic elliptic-rectangular shape, 12.3–19.7 μm long and 4.9–12.3 μm wide. On the abaxial epidermis are found very numerous, unicellular, simple trichomes, 41.8–115.6 μm long with unicellular, elliptic-elongated trichome base, 9.8–14.8 μm in size.

Remarks. The leaves are assigned to *Acer tricuspidatum* Bronn sensu Procházka & Bůžek on the basis of their morphology (trilobate leaves with characteristically serrate margins) and epidermal structure (the shape of stomata and the presence of unicellular, simple trichomes on the abaxial epidermis).

Acer tricuspidatum is classified within sectio *Rubra* Pax (Walther 1972, Procházka & Bůžek 1975) and is related to the contemporary species *A. rubrum* L. and *A. saccharinum* L. (Hantke 1954, Kräusel & Weyland 1959). The epidermal morphology of extant *A. rubrum*, *A. saccharinum* and *A. hyrcanum* Frisch. & Mey are comparable with that of fossil *A. tricuspidatum* (Walther 1972). According to Kräusel and Weyland (1959) there are no differences in epidermal structure between *A. tricuspidatum* and *A. rubrum*.

Acer tricuspidatum is known from Central Europe from the Middle Oligocene to the

Pliocene. It was most frequently present during the Miocene, when at the end of this epoch it began to disappear in Central Europe, and in the Pliocene it still remained in southern Europe, e.g. in Bulgaria and Italy (Procházka & Bůžek 1975). This species is considered to constitute a component of swampy vegetation in the Neogene of Central Europe (Walther 1972). Kovar-Eder et al. (2001) considered *A. tricuspidatum* as a riparian element in the Miocene flora of Oberdorf.

Occurrence in the fossil floras of Poland. Early Miocene – Osieczów (Raniecka-Bobrowska 1962, as *Acer trilobatum*), Bełchatów (Worobiec 2003); Middle Miocene – Kokoszyce (Meyer 1919, as *Acer trilobatum*), Dobrzyń on the Vistula River (Kownas 1956, as *Acer* sp. (*Acer trilobatum*)), Stare Gliwice (Szafer 1961, as *Acer trilobatum*), Młyny (Zastawniak 1980); Late Miocene – Sośnica (Kräusel 1921, Walther & Zastawniak 2005); and Miocene – Pierusza (Kräusel 1921) as *Acer trilobatum*; Early Pliocene – Ruszów (Hummel 1983), Nysa (Krajewska 2001).

***Acer* sp.**

Fig. 6: 1; Pl. 2, fig. 7

Material. KRAM-P 243: C/5/III, C/12/III (counterpart to 243/C/5/III), D/24; KRAM-P 244: B/38.

Macromorphology. Entire-margined fragments of leaves with actinodromous basal venation. Primary vein branched into between 3 and 5 branches. The tertiary venation similar to genus *Acer*.

Remarks. The leaves described undoubtedly belong to maple. Identification to species is impossible due to the incompleteness of the specimens.

***Acer* sp. ex gr. *Rubra* Pax**

Pl. 2, figs 3, 6

Material. KRAM-P 243: C/3/I, C/5/IV; KRAM-P 244: B/22/III.

Macromorphology. Maple samaras, 1.5–2.2 cm long and 0.5–0.9 cm wide (in the widest place). Samaras have distinct and dense venation. The seed impression appears elliptic/oblate, 0.6–0.9 cm long and about 0.4 cm wide.

Remarks. The fruits are maple samaras, probably belong to single species. Their shape suggests affinity with the samaras of recent *Acer rubrum* L.

Betulaceae Gray

***Alnus* Miller**

***Alnus julianiformis* (Sternberg) Z. Kvaček & Holý**

Pl. 9, fig. 5, Pl. 10, fig. 1

1823 *Phyllites julianaeformis* Sternberg, pp. 37, 39, pl. 36, fig. 2.
1974 *Alnus julianaeformis* (Sternberg) Z. Kvaček & Holý, p. 367, Fig. 1, pl. 1–3, pl. 4, fig. 1.
1998 *Alnus julianiformis* (Sternberg) Z. Kvaček & Holý; Zastawniak & Walther, p. 100, Figs 5: 1–17, Figs 6: 1–4, pl. 7, figs 2–5, 7, 9–10, pl. 8, figs 1–4, 8, 10.

Material. KRAM-P 243: B/14, B/32.

Macromorphology. Fragments of leaves, up to 3.5 cm long and 2.7 cm wide. Leaf base obtuse. Leaf margin simple serrate, teeth small, apical sides of teeth very short, straight or concave, basal sides long, straight, convex or acuminate, tooth apex acute. Fine veins arise from the secondary veins and branch with one branch terminating in the tooth apex, and the other terminating in the adjacent sinus. Venation craspedodromous, with exception of the lowermost veins which are brochidodromous. Primary vein straight, moderately thick. Secondary veins arising from the primary vein at intervals of about 0.5 cm near leaf base and forming an angle of about 60° with it near the leaf base. Secondaries curving upward, lowest interconnected in loops. Tertiary venation seems to be weakly percurrent.

Micromorphology. Adaxial epidermis composed of isodiametric or slightly elongated cells, 12.3–29.5 μm in size with straight, rounded and fine undulate cell walls. Cuticle granular (probably epicuticular wax). Abaxial epidermis composed of more or less isodiametric cells, 14.7–24.6 μm in size. Leaves hypostomatic. Stomata anomocytic, wide elliptic to elliptic, distinctly variably-sized, 17.2–27.0 μm in size. Outer stomatal ledge aperture spindle-shaped or wide spindle-shaped, 9.8–17.2 μm long and 3.7–7.4 μm wide. On the abaxial epidermis and sometimes on adaxial epidermis are found multicellular (mostly 4, up to 7 cells) trichome bases, 18.5–27.0 μm in size. Preserved peltate glandular trichomes measured 49.0–60.0 μm in diameter.

Remarks. These specimens, with their distinctive serration, venation pattern and epidermal structure, were assigned to *Alnus julianiformis* (Sternberg) Z. Kvaček & Holý. Macromorphologically, the leaves of *A. julianiformis* are similar to *A. gaudinii* (Heer) Knobloch & Z. Kvaček, but differ by having simple craspedodromous venation, symmetric leaf bases and less cutinised epidermis without perpendicular cuticular striations around the stomata (Knobloch & Kvaček 1976, Zastawniak & Walther 1998). *Alnus julianiformis* was a common species in European Neogene floras (see Hummel 1991), and probably was a component of riparian and swamp forests. With respect to morphology, the most similar contemporary species is *A. japonica* Sieb. & Zucc. growing in Japan, China and in eastern Russia (Czeczott 1934). However, it differs from *A. julianiformis* in its epidermal structure (Kvaček & Holý 1974, Hummel 1991). *A. trabeculosa* Hand.-Mazz., growing in mixed mesophytic forests in the Yangtze Valley in China (Wang 1961), has the epidermis most similar to that of *A. julianiformis* (Hummel 1991). However, it slightly differs in leaf morphology having rounded or cordate asymmetric bases and more numerous secondary veins.

Occurrence in the fossil floras of Poland. Early Miocene – Bełchatów (Worobiec 1995, 2003); Middle Miocene – Młyny (Zastawniak 1980); Late Miocene – Sośnica (Knobloch 1971, Zastawniak & Walther 1998); Early Pliocene – Ruszów (Hummel 1991).

Alnus menzelii Raniecka-Bobrowska

Fig. 3: 10; Pl. 2, fig. 8, Pl. 3, fig. 1, Pl. 7, fig. 1, Pl. 10, figs 2, 3, 4

1954 *Alnus menzelii* Raniecka-Bobrowska, p. 11, Fig. 4, Phot. 11-13.

Material. KRAM-P 243: B/20, D/13, KRAM-P 244: B/8/II, B/20/I, B/25/I, B/37/I, B/39/III, B/42/I, B/44 and B/45 (counterparts), C/6, C/8/II, C/10, C/11/II, C/13, C/16/II, C/18, C/20/II, C/22/II, C/25 (counterpart to C/11).

Macromorphology. Leaves up to 7.5 cm long and up to 6.5 cm wide, leaf base always cordate, often asymmetric. Leaf margin doubly serrate, primary teeth large and so resemble lobes, secondary teeth much more smaller. Apical and basal sides of teeth acuminate or convex, tooth apex acute or rounded (mostly apex of secondary teeth). Secondaries terminate in primary teeth, branches of secondaries terminate in secondary teeth. Preserved petioles up to 1.5 cm long, sometimes bent and thick. Venation simple craspedodromous, at the leaf base often brochidododromous. Primary vein straight, sometimes curved, of moderate thickness. Up to 13 preserved pairs of secondary veins were found. First pair of secondary veins form an angle of 90–110° with primary vein, next pair 70–90°. In the middle part of leaf blade this angle decreases to 40–60° (mostly 50–60°). Secondaries slightly curved upward, arranged at intervals ranging from 0.15–0.20 cm near leaf base to 0.4–1.1 cm in the middle part of leaf. Tertiary venation percurrent, forming an angle of 135–155° with primary vein; tertiary veins simple or forked, 5 to 7 (9) per 1 cm of the secondary vein length. Higher–order venation orthogonal reticulate. Areoles well developed, about 0.5 mm in size. Veinlets branched.

Micromorphology. Adaxial epidermis composed of isodiametric to elongate, variable shaped cells, 9.8–34.4 μm in size. Anticlinal cell walls mainly straight. Cuticle of adaxial epidermis usually (but not always) distinctly striated. Cells of abaxial epidermis of variable shape, 9.8–39.4 μm in size, anticlinal cell walls straight, rounded or characteristically undulate. Leaves hypostomatic. Stomata anomocytic, elliptic, wide elliptic, occasionally rounded, 16–27 μm in diameter. Outer stomatal ledge aperture spindle-shaped or wide spindle-shaped, distinctly cutinized and sharpened at the poles, distinctly variably-sized, 7.4–22.1 μm long and 2.5–9.8 μm wide. On the abaxial epidermis, multicellular, mostly 4-, occasionally 3- or 5- celled trichome bases were found. Glandular, peltate trichome shield 49.2–61.5 μm in diameter, trichome bases 19.7–32.0 μm in size.

Remarks. *Alnus menzelii* Raniecka-Bobrowska is characterized by leaves always having cordate and sometimes slightly asymmetric bases, a doubly serrate leaf margin and well-marked branches of lateral veins at the leaf base. Macromorphologically, the leaf

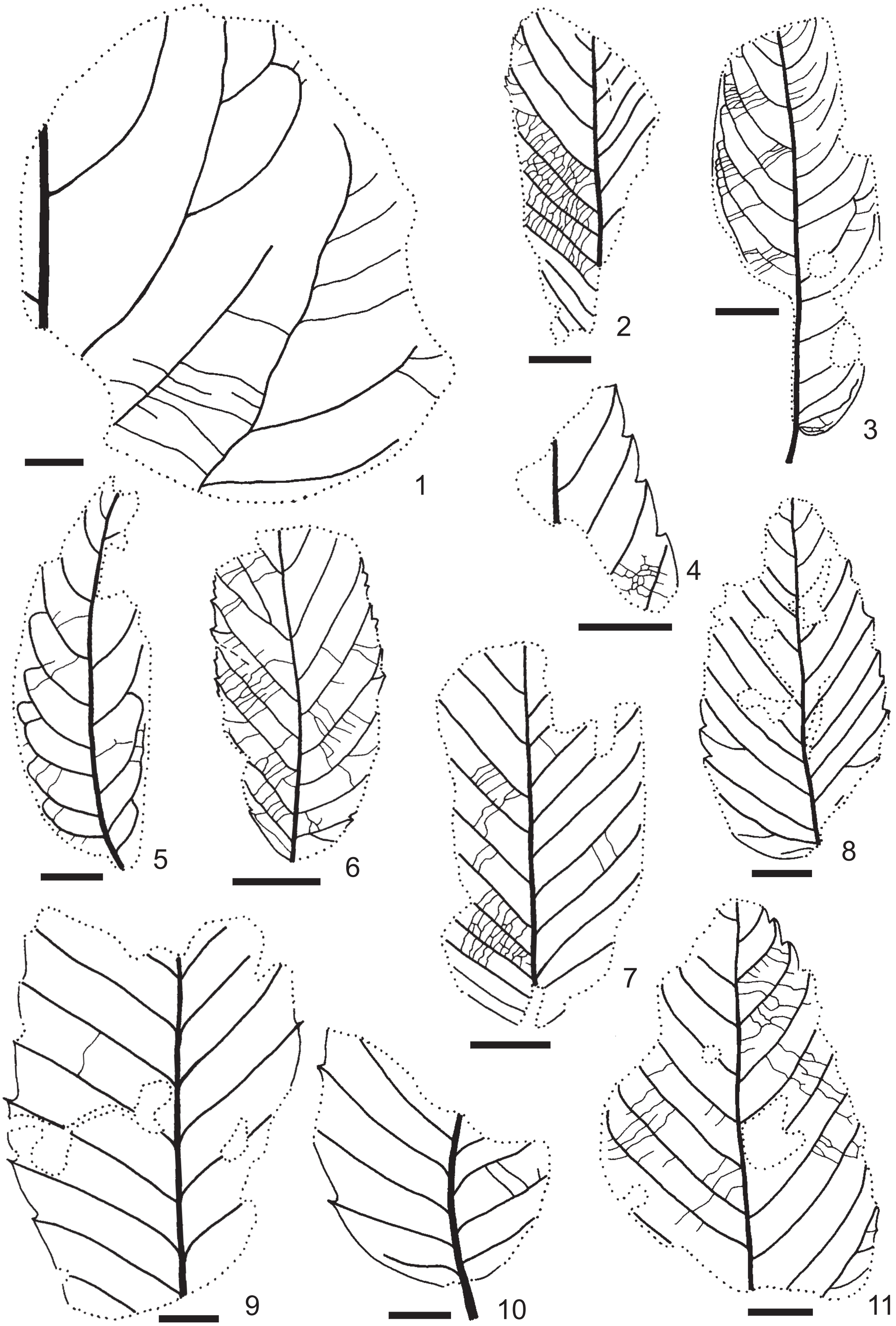

Fig. 5. 1 – cf. *Populus* sp., specimen KRAM-P 244/B/3; **2** – *Ulmus* cf. *ruszovensis* Hummel, specimen KRAM-P 243/D/3/II; **3** – *Salix* cf. *kicktonii* Weyland, specimen KRAM-P 244/B/8/I; **4** – *Zelkova zelkovifolia* (Unger) Bůžek & Kotlaba, specimen KRAM-P 244/B/43; **5** – *Pterocarya paradisiaca* (Unger) Ilinskaya, specimen KRAM-P 243/D/3/III; **6, 7, 11** – *Ulmus* sp.: **6** – specimen KRAM-P 244/C/3/I, **7** – specimen KRAM-P 244/B/6/I, **11** – specimen KRAM-P 244/C/14; **8** – *Ulmus pseudopyramidalis* Z. Kvaček & Hably, specimen KRAM-P 244/B/22; **9–10** – *„Castanea” kubinyii* Kováts ex Ettingshausen sensu Knobloch & Z. Kvaček: **9** – specimen KRAM-P 243/D/22, **10** – specimen KRAM-P 243/D/9. Scale bar – 1 cm

remains match exactly to the description of *A. menzelii* from the Miocene of Konin (Raniecka-Bobrowska 1954).

Alnus menzelii has only been recorded from few Neogene fossil floras though according to Zastawniak and Walther (1998) this species was rather common (see also Worobiec and Szynkiewicz 2007). However, leaves of this species could have been mistaken for those of other fossil taxa representing the family Betulaceae where morphological similarities are great, e.g. *A. kefersteinii* (Goeppert) Unger, *Betula brongniartii* Ettingshausen, *B. prisca* Ettingshausen (Zastawniak & Walther 1998) or *B. macrophylla* Heer (Worobiec 2003).

Alnus menzelii was a typical component of riparian and swampy forests (Zastawniak & Walther 1998). According to Raniecka-Bobrowska (1954) *Alnus menzelii* is the most similar to two contemporary alder species: *A. serrulata* (Ait.) Willd. from forests growing in the eastern part of North America and *A. subcordata* C.A. Meyer from Asia Minor (Transcaucasia, Iran).

Occurrence in the fossil floras of Poland. Middle Miocene – Koronowo (as *Corylus mac quarri* (Forbes) Heer, Menzel 1910, Raniecka-Bobrowska 1954), Konin (Raniecka-Bobrowska 1954); Late Miocene – Bełchatów (Stuchlik et al. 1990, Worobiec 2003), Gnojna (Krajewska 1998), Sośnica (Zastawniak & Walther 1998); Late Miocene/Early Pliocene – Bełchatów (Worobiec & Lesiak 1998), Early Pliocene – Ruszów (Hummel 1983).

Carpinus L.

cf. ***Carpinus grandis*** Unger **emend.** Heer

Fig. 4: 4; Pl. 2, fig. 4

1850a *Carpinus grandis* Unger, p. 408.
1852 *Carpinus grandis* Unger, p. 39, pl. 20, figs 4, 5.
1856 *Carpinus grandis* Unger; Heer, pl. 71, figs 19b, c–e, pl. 72, figs 2–11, 14, 16, 17, 19, 20, 22–24, pl. 73, figs 2–4.

Material. KRAM-P 244: B/19/II.

Macromorphology. Leaf fragment, 6.0 cm long and 3.3 cm wide. Leaf base probably slightly cordate. Ten pairs of secondary veins, arranged oppositely, depart the primary vein at intervals of about 0.3 cm near leaf base and 0.6–0.9 cm in the middle part of lamina. Lowermost secondary veins form an angle of about 65° with primary vein and remaining veins about 45°. Lowermost secondaries branched. Tertiary venation percurrent. Tertiaries form an angle of ca. 120° with the primary vein.

Remarks. Leaf fragment most probably belongs to the species *Carpinus grandis* Unger emend. Heer as indicated by the characteristic venation pattern near the leaf base (comp. Fig. 4: 4, in this paper with pl. 10, fig. 2a in Worobiec and Szynkiewicz 2007). Leaves of *Carpinus* are common in the Neogene of Central Europe and are considered to be a component of mesophytic vegetation (comp. Kovar-Eder 2003).

Occurrence in the fossil floras of Poland. Early Miocene – Rozewie (Heer 1869), Parowa (Kräusel 1920); Middle Miocene – Kokoszyce, Stróża, (Reimann 1919), Chodzież (Zabłocki 1924), Dobrzyń on the Vistula River (Kownas 1956), Czernica (Raniecka-Bobrowska 1957), Swoszowice (Ilinskaya 1964), Stare Gliwice (Zastawniak 1980); Late Miocene – Sośnica (Goeppert 1855, Reimann 1919, Łańcucka-Środoniowa et al. 1981, Zastawniak & Walther 1998), Bełchatów (Stuchlik et al. 1990), Gnojna (Krajewska 1998); Miocene – Brzeg Dolny, Chroślice, Domaradz, Trzebnica, Wróblin, Zielona Góra, (Reimann 1919), Pierusza (Kräusel 1920); Pliocene – Domański Wierch (Zastawniak 1972).

Malvaceae Juss. (1789) nom. cons. *sensu* APG II 2003

Byttneriophyllum Givulescu ex Knobloch & Z. Kvaček

Byttneriophyllum tiliifolium (A. Braun) Knobloch & Z. Kvaček

Fig. 3: 8, Fig. 4: 1; Pl. 3, figs 3–5, Pl. 7, fig. 2, Pl. 10, figs 5, 6, Pl. 11, figs 1–3

1845 *Cordia tiliaefolia* A. Braun, p. 170.
1856 *Ficus tiliaefolia* A. Braun, Heer, pp. 68–69, 108, pl. 43, fig. 3(?), 6–8, 9(?), 10–11, 12(?), pl. 44, fig. 1–5.
1919 *Büttneria aequalifolia* (Goeppert) Fr. Meyer, p. 174, pl. 17, figs 2–4, pl. 26, fig. 12.
1965 *Byttneriophyllum tiliaefolium* (A. Braun) Knobloch & Z. Kvaček, p. 128, pl. 1, figs 1–3, pl. 2, figs 1–2, pl. 3, fig. 2, pl. 4, figs 1–2, pl. 5, figs 1-6, pl. 6, figs 1–3.

Material. KRAM-P 243: B/18/II, B/24, B/26, B/27, B/33 (counterpart to B/26), B/35/I, D/14/II, D/20, D/23, D/26, D/32, D/34 (counterpart to D/26), D/36, D/38/I, D/39, D/41; KRAM-P 244: B/5/III, B/10/II, B/12/II, B/17/II, B/20/II, B/27, B/28/I, B/31, B/33, B/39/I, B/42/III, C/16/I, C/20/I, D/2/I and D/3/I (counterparts), D/5, D/33, B/14/I, D/2, D/5.

Macromorphology. Fragments of entire-margined leaves with attenuate apex and cordate, usually asymmetric base. Petiole pulvinate. Venation actinodromous, basal. Primary vein branched into between 6 and 9 branches. Secondary veins curve upward, arranged at wide intervals. Secondary veins and primary vein branches interconnected in loops. Tertiary venation regularly percurrent, about 3–8 (commonly 4–6) tertiary veins occur per 1 cm of secondary vein length. Higher order venation orthogonal reticulate. Areoles well developed, small, 0.10–0.20 mm in size. Veinlets usually absent, if present, simple.

Micromorphology. Adaxial epidermis composed of isodiametric, occasionally slightly elongated cells, 9.8–24.6 μm in size. Anticlinal cell walls predominantly straight, occasionally rounded. In respect of cuticle ornamentation two types of leaves were found: without cuticle ornamentation and with dense, sometimes hardly visible reticulate ornamentation. On the adaxial epidermis glandular trichomes, probably similar type to the clavate-like were found. They are usually short (exceptionally up to 37 μm long), with unicellular, nearly rounded, trichome base, 12.3–17.2 μm in diameter. Abaxial epidermis consists of variably-shaped, frequently elongated cells, 9.8–22.1 μm in size, over the veins strongly elongated. Anticlinal cell walls straight or rounded, occasionally wide undulate. Leaves hypostomatic. Stomata anomocytic, rounded to wide elliptic, variably-sized, 12.3–24.6 μm in size. Outer stomatal ledge aperture usually spindle-shaped, occasionally elliptic, variably-sized, 6.1–16.0 μm long and 2.5–7.4 μm wide. Stomatal pore occasionally visible. On the abaxial epidermis two types of trichomes can be found. Usually most numerous are stellate trichomes, composed of 6–8 arms, up to 110 μm in diameter with irregularly elliptic-oval trichome base, 13.5–29.5 μm in size. Density of stellate trichomes depends of the leaf: from relatively seldom to very abundant, forming dense cover. Glandular, clavate trichomes, usually rare, composed of commonly 6, occasionally 5 to 9 cells, measure 22.1–41.8 μm long and 14.7–22.0 μm wide. One celled base of clavate trichomes elliptic-rounded, measure 9.8–14.7 μm in diameter.

Remarks. The shape and the venation of these leaves are characteristic of the extinct taxon of *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Z. Kvaček. The leaves are entire-margined, suborbiculate to nearly orbiculate in shape, often with a cordate, asymmetric base, with actinodromous venation and a regular network of tertiary veins. The abaxial epidermis of these leaves bear both stellate, trichomes and simple, glandular, clavate trichomes. The leaves of another fossil species *Dombeyopsis lobata* Unger are similar to *Byttneriophyllum tiliifolium*. However, *Dombeyopsis lobata* has mostly lobate leaves with a less dense and not so regular network of tertiary veins and areoles approximately twice as large.

Byttneriophyllum tiliifolium was included in the family Sterculiaceae (Givulescu 1979, Sitár & Takač 1993). However, according to Knobloch and Kvaček (1965) it may belong to either the Sterculiaceae or the Tiliaceae, as leaves with a similar morphology and epidermal structure occur in extant genera of these two families. In the result of contemporary taxonomic studies Tiliaceae and Sterculiaceae as well as Bombacaceae and Malvaceae were merged together into one single family, Malvaceae Juss. nom. cons. (APG II 2003).

Byttneriophyllum tiliifolium has been recognized as a component of swampy vegetation in the Neogene flora of Central Europe (Knobloch & Kvaček 1965), common in Central Europe during the Middle and Late Miocene (Zastawniak et al. 1996, Hably and Kovar-Eder 1996). The species is known to have occurred in coal-forming communities and has been found in association with *Glyptostrobus europaeus* (Brongniart) Unger and species of the genera *Acer*, *Alnus*, *Betula*, *Cercidiphyllum*, *Osmunda*, *Populus*, and *Salix* (Givulescu 1992, Mai 1995, Hably & Kovar-Eder 1996).

Occurrence in the fossil floras of Poland. Early Miocene – Turów (Czeczott 1967) as *„Ficus" tiliaefolia* Heer; Middle Miocene – Koronowo (Menzel 1910) as *Ficus tiliaefolia* A. Br. sp.), Stróża (Kräusel 1920) as *Büttneria aequalifolia* (Goeppert) Fr. Meyer, and Trzcianka (Raniecka-Bobrowska 1970), Bełchatów (Stuchlik et al. 1990); Late Miocene – Bełchatów (Worobiec 2003); Miocene – Kunice Żarskie (Engelhardt 1877) and Rataje (Menzel 1910) as *Ficus tiliaefolia* A. Br., and Wołów (Kräusel 1919), Zielona Góra (Kräusel 1920), Pierusza, Wichów (Kräusel 1921) and Smogorzówek, (Raniecka-Bobrowska 1970) as *Büttneria aequalifolia*, and Nysa (Krajewska 2001).

cf. ***Byttneriophyllum tiliifolium*** (A. Braun) Knobloch & Z. Kvaček

Material. KRAM-P 243: A/20.

Remarks. Specimen similar to *Byttneriophyllum tiliifolium* but too poorly preserved for unambiguous identification.

„Ficus" truncata Heer sensu Bůžek

Fig. 3: 7; Pl. 3, fig. 2, Pl. 11, fig. 4

1859 *Ficus truncata* Heer, p. 183, pl. 152, fig. 15.
1971 *„Ficus" truncata* Heer; Bůžek, pp. 92–94, Fig. 15, pl. 46, figs 1–9, pl. 47, figs 1–8, pl. 48, figs 1–4.

Material. KRAM-P 244: C/8/I.

Macromorphology. Fragment of leaf, poorly preserved. Venation actinodromous, primary vein branched into 6 branches. Tertiary venation weakly percurrent, about 2–4 tertiaries occur per 1 cm of the secondary vein length.

Micromorphology. Adaxial epidermis composed of isodiametric or slightly elongated cells, 19.7–36.9 μm in size, over the veins cells are more elongate. Anticlinal cell walls wide undulate. Abaxial epidermis consists of variable-shape cells, 24.6–46.7 μm across with undulate anticlinal cell walls. Over the veins cells strongly elongate, up to 56.6 μm long. Leaf hypostomatic. Stomata anomocytic, elliptic, 16.0–29.5 μm in size, cell wall of guard cells are often invisible. Outer stomatal ledge aperture commonly spindle-shaped, occasionally elliptic-elongate, strongly variably-sized, 7.4–19.7 μm long and 3.7–11.0 μm wide. Some of stomata (the largest) surrounded by cuticular striations perpendicular to the stomatal pore. On the abaxial epidermis two types of trichomes were found. Most numerous were stellate trichomes, composed of several arms, with multicellular base of 22.1–36.9 μm in size. Glandular, clavate trichomes were occasionally found and composed of usually 4 cells, 36.0–41.8 μm long and 12.3–14.7 μm wide with unicellular base, 9.8–12.3 μm in diameter.

Remarks. The leaf fragment is the most similar to *„Ficus" truncata* Heer from Oehningen (Heer 1859). *„Ficus" truncata* is macromorphologically similar to *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Z. Kvaček (Bůžek 1971), differing from it in its venation pattern of the third order. The first authors' observations show that these taxa also differ in their epidermal structure. *„Ficus" truncata* from Ruja has 4–celled glandular trichomes, while similar trichomes of *B. tiliifolium* are commonly 6–celled.

„Ficus" truncata belongs to the family Malvaceae Juss. nom. cons. *sensu* APG II 2003 which is evident from macro- and micromorphology of its leaves (Kvaček 2006). Recently Kvaček (op. cit.) found abundant accumulations of leaves of this taxon being associated with fruits of *Reevesia hurnikii* Kvaček. It is very probable that leaves of *„Ficus" truncata* in fact belong to the genus *Reevesia*, as leaves of *„Ficus" truncata* matches in their macromorphology some species of the genus *Reevesia* from SE China (Kvaček 2006).

Occurrence in the fossil floras of Poland. Middle Miocene – Bełchatów (Stuchlik et al. 1990, Worobiec 2003).

cf. ***„Ficus" truncata*** Heer sensu Bůžek

Fig. 3: 4; Pl. 3, fig. 6

Material. KRAM-P 243: D/27; KRAM-P 244: B/5/II.

Remarks. Specimens similar to *„Ficus" truncata* Heer sensu Bůžek but too poorly preserved for unambiguous identification.

Byttneriophyllum tiliifolium (A. Braun) Knobloch & Z. Kvaček vel ***„Ficus" truncata*** Heer sensu Bůžek

Material. KRAM-P 244: D/1/I, D/4/II, D/3.

Remarks. Specimens similar both to *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Z. Kvaček and *„Ficus" truncata* Heer sensu Bůžek but too poorly preserved for unambiguous identification.

Cercidiphyllaceae Engler

Cercidiphyllum Siebold & Zuccarini

Cercidiphyllum* (?) *crenatum (Unger) R. W. Brown emend. Z. Kvaček & Konzalová

Fig. 6: 2; Pl. 6, fig. 3, Pl. 7, fig. 3, Pl. 11, fig. 5b

1850a *Dombeyopsis crenata* Unger, p. 448.
1935 *Cercidiphyllum crenatum* (Unger) R. W. Brown, p. 575, pl. 68, figs 1, 6, 8–10.
1996 *Cercidiphyllum crenatum* (Unger) R. W. Brown emend. Z. Kvaček et Konzalová, pp. 147–155, pl. 1, figs 1–4, pl. 2, figs 2–8, pl. 3, figs 3–7, pl. 4.

Material. KRAM-P 244: C/12/I.

Macromorphology. Leaf suborbicular, ca. 5 cm long and 6.5 cm wide, base cordate. Margin simple serrate or crenate. Apical and basal sides of teeth convex, tooth apex rounded, teeth about 0.3 cm long. Venation actinodromous, perfect, basal, reticulate. Primary vein branched into 9 branches, near leaf base vein branches densely covered by trichomes. Tertiary venation percurrent or weakly percurrent. Higher order venation orthogonal reticulate. Areoles imperfectly (?) developed, very large, 1.5–2.0 mm in size. Veinlets multiple branched.

Micromorphology. Adaxial epidermis composed of isodiametric or slightly elongated cells, often quadrangular, with straight or rounded walls, 27.0–44.3 μm in size, over the veins cells elongated and narrow.

Remarks. Suborbiculate leaf with serrate/crenate margin and characteristic very large areoles points to fossil *Cercidiphyllum crenatum* (Unger) R. W. Brown emend. Z. Kvaček & Konzalová. The holotype of the species described by Unger (1850a) was lost. Kvaček and Konzalová (1996) on the basis of preserved specimen from collection from the type locality of Hoher Rhonen established a neotype and

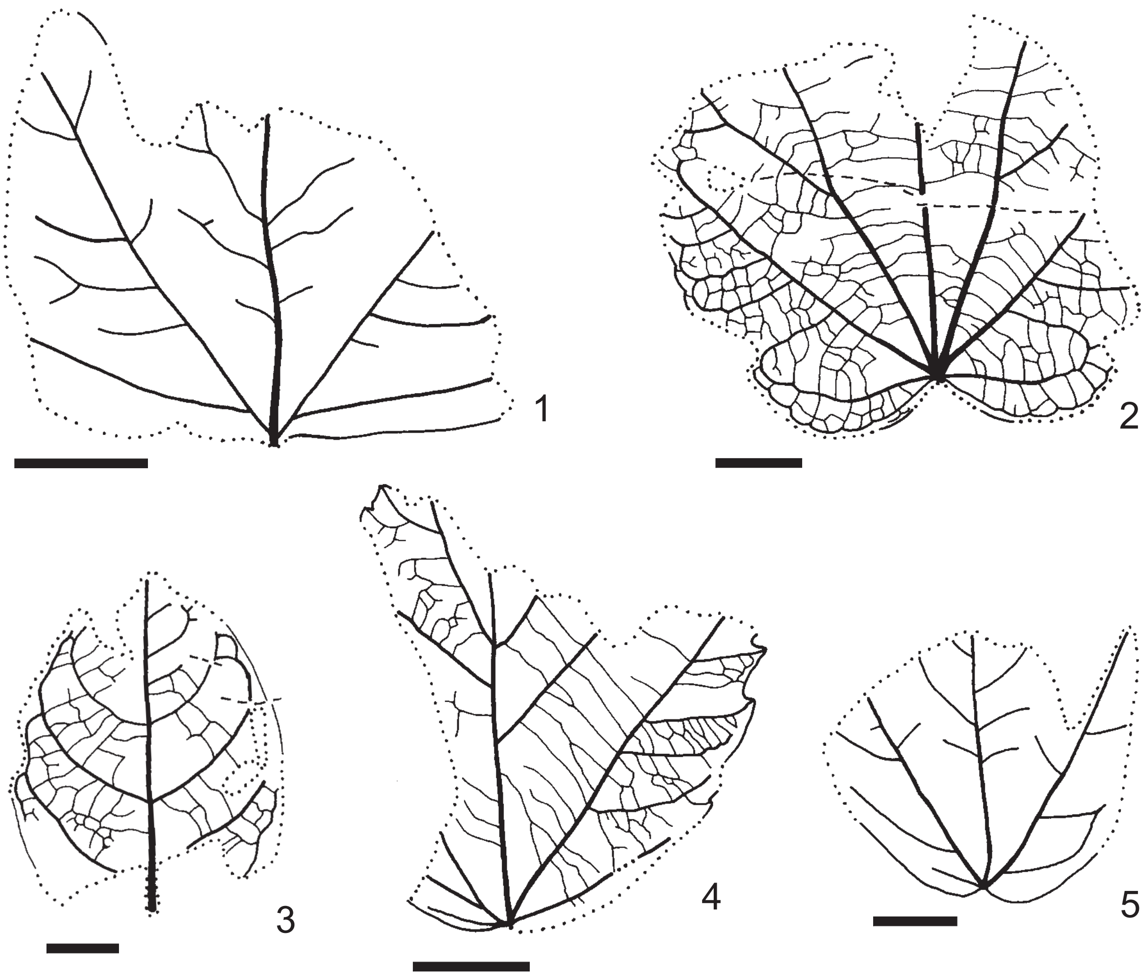

Fig. 6. 1 – *Acer* sp., specimen KRAM-P 243/C/12/III; **2** – *Cercidiphyllum* (?) *crenatum* (Unger) R. W. Brown emend. Z. Kvaček & Konzalová, specimen KRAM-P 244/C/12/I; **3** – *Dicotylophyllum* sp. 4, specimen KRAM-P 243/D/40; **4** – *Dicotylophyllum* sp. 2, specimen KRAM-P 244/C/3/II; **5** – Dicotyledones indeterminatae, specimen KRAM-P 243/D/31. Scale bar – 1 cm

prepared an emended diagnosis of *C. crenatum*. Although comparison of *Cercidiphyllum* from Ruja with the neotype diagnosis confirms identification of the genus, some differences were found. The leaf from Ruja has a dense cover of trichomes on the basal part of primary vein branches and more numerous branches of primary vein (9) in comparison with the neotype of *C. crenatum*. It is possible that *Cercidiphyllum* from Ruja could represent a new species, but on the basis of one leaf creation of a new taxon seems not to be reliable.

Cercidiphyllum crenatum was widely distributed in the Neogene in Europe (especially in Miocene), in Asia and North America. It is considered to be a component of the Neogene fluviatile, moist lowland forest vegetation (Kvaček & Konzalová 1996, Kovar-Eder et al. 1998), possibly also of swampy communities (Kvaček & Konzalová 1996). Contemporary *C. japonicum,* is the only extant descendant of *C. crenatum* today growing in Japan and China in moist valley mountainous forests (Kvaček & Konzalová, op. cit.).

Occurrence in the fossil floras of Poland. Early Miocene – Turów; Middle Miocene – Koronowo, Swoszowice; Miocene – Pierusza, Smogorzówek (see Hummel 1970, 1975). More often were found remains of fruits described as *Cercidiphyllum helveticum* Jähnichen, Mai & Walther (Zastawniak et al. 1996).

Myricaceae Kunth

Myrica L.

Myrica lignitum (Unger) Saporta *sensu lato*

Fig. 4: 5; Pl. 3, fig. 7, Pl. 12, figs 1, 2

1847 *Quercus lignitum* Unger, p. 113, Pl. 31, figs 5–7.
1865 *Myrica lignitum* (Unger) Saporta, p. 102.

Material. KRAM-P 243: A/2; KRAM-P 244: B/34/I.

Macromorphology. Fragmentary, elongate leaves, up to 5.2 cm long and 1.5–1.9 cm wide. Leaf base cuneate and decurrent. Only entire-margined leaves were found. Petiole up to 0.5 cm long. Venation brochidodromous. Primary vein straight, stout. Numerous thin secondary veins run off primary vein at intervals of 0.4–0.8 cm and form an angle of 60–75° with it. Secondaries curving upward and near the leaf margin, interconnecting in loops. Intersecondary veins present, distinct. Tertiary venation forming a composite network with the intersecondary veins. Higher order venation random reticulate.

Micromorphology. Adaxial epidermis composed of isodiametric or elongated cells, 9.8–34.4 μm in size. Anticlinal cell walls straight, rounded, sometimes slightly undulate. Abaxial epidermis consists of irregular-shaped, frequently elongated cells, 8.6–27.0 μm in size. Anticlinal cell walls rounded or undulate. Leaves hypostomatic. Stomata anomocytic, rounded or widely elliptic, 12.3–24.6 μm in diameter. Outer stomatal ledge aperture elliptic, wide elliptic or rounded, 6.1–12.3 μm in size. Stomatal pore occasionally visible. On the abaxial epidermis numerous glandular, entire margined peltate trichomes were found. Two-celled (exceptionally 4-celled) trichome base, irregularly-elliptic, 17.2–24.6 μm in size. Trichome shield multicellular, composed of radiately arranged cells, 68.9–88.6 μm in diameter. Inside a few trichomes were preserved the remains of resinous secretion.

Remarks. Macro- and micromorphology of leaf fragments is similar to *Myrica lignitum* (Unger) Saporta *sensu lato*. Their shape, venation pattern, and epidermal peltate glandular trichomes with two-celled bases represent characteristic features. It differs from *Myrica joannis* Ettingshausen emend. Kovar-Eder in their entire-margined leaves (Kovar-Eder 1996) and from *M. undulatissima* Knobloch & Kvaček in mostly rounded cell walls of abaxial epidermis and rounded shields of peltate trichomes (Knobloch & Kvaček 1976). Untypical for *M. lignitum* is the presence of only entire-margined leaves. It is probably due to scarcity of the material (only two leaf fragments), but it should not be excluded that discussed *Myrica* leaves possibly represent some other species, most probably that of *M. integerrima* Kräusel & Weyland.

Fossil leaves of *Myrica* are macromorphologically very similar to fossil leaflets of the genus *Engelhardia* Lesch. ex Bl. (Juglandaceae). The differences in leaves between this two genera are asymmetrical shape of *Engelhardia* leaflets that are mostly distinctly smaller than *Myrica* leaves and the one-celled bases of peltate glandular trichomes on the abaxial epidermis in *Engelhardia*.

Myrica lignitum is a common element of Neogene fossil floras, an indicator of the presence of swampy vegetation. In respect of morphology the species resembles several representatives of the genus *Myrica* from North America, east Asia, or even tropical mountain forests from Africa (Ilinskaya 1964, Knobloch 1969).

Occurrence in the fossil floras of Poland. Early Miocene – Bełchatów (Worobiec 1995, Worobiec 2003); Middle Miocene – ?Dobrzyń on the Vistula River (Kownas 1956), Swoszowice (Ilinskaya 1962, 1964); Late Miocene – Bełchatów (Stuchlik et al. 1990, Wójcicki & Zastawniak 1998, 2003, Worobiec 2003); Early Pliocene – Ruszów (Hummel 1983). In the opinion of Knobloch and Kvaček (1976) fossil leaves reported as *Myrica pseudolignitum* Kräusel & Weyland from Stare Gliwice by Szafer (1961) belong to *Buxus pliocenica* Saporta. Leaves of *Myrica* from Dobrzyń on the Vistula River (Kownas 1956) reported as *M. amissa* Heer and *M. studeri* Heer most probably belong to *M. lignitum*.

cf. ***Myrica lignitum*** (Unger) Saporta *sensu lato*

Pl. 3, fig. 8

Material. KRAM-P 243: B/4 and B/9 (counterparts); KRAM-P 244: B/26/II.

Remarks. Fragments of leaves similar to *Myrica lignitum*. Their poor state of preservation (no cuticular data) precludes unequivocal assignment.

Salicaceae Mirbel

Populus L.

Populus populina (Brongniart) Knobloch

Fig. 3: 9, 11; Pl. 6, fig. 2, Pl. 12, figs 3, 4, Pl. 13, fig. 1

1822 *Phyllites populina* Brongniart, p. 237, pl. 14, fig. 4.
1836 *Populus latior* A. Br.; A. Braun in Buckland, p. 512.
1964 *Populus populina* (Brongniart) Knobloch, p. 601.

Material. KRAM-P 244: B/6/II, B/15/I, B/32.

Macromorphology. Fragments of leaves with acute or attenuate apex and simple serrate margin. Teeth straight or hook-shaped, variable spaced, apical side of tooth concave, basal side of tooth straight, concave or acuminate, tooth apex from rounded (near leaf base) to acute or even attenuate (in the upper part of leaf). Branches of secondary veins terminate in secondary tooth apex. Venation semicraspedodromous. Primary vein straight, stout. Secondary veins run off primary vein at intervals of 1.4–2.0 cm and form an angle of about 40–60° with it. Secondaries curved upward, strongly branched. Intersecondary veins present. Tertiary venation composite intersecondary or weakly percurrent. Higher order venation random reticulate.

Micromorphology. Adaxial epidermis composed of isodiametric or slightly elongated cells, 14.8–36.9 μm in size. Anticlinal cell walls predominantly straight. Over the veins cuticle with epicuticular wax coating or reticulate ornamentation. Abaxial epidermis consists of irregular-shaped, isodiametric or slightly elongated cells, 12.3–32.0 μm in size. Anticlinal cell walls frequently bent, sometimes rounded or even straight. Leaves hypostomatic. Stomata characteristically quadrangular (frequently rectangular), 19.7–44.2 μm in size. Stomata are surrounded by stout striae. Outer stomatal ledge aperture from narrow to wide spindle-shaped, occasionally narrow elliptic, 7.4–22.1 μm long and 3.7–9.8 μm wide, surrounded by perpendicular, very stout and bent striae. On the abaxial epidermis trichome bases, unicellular, irregularly-elliptic, 7.4–12.3 μm in size, surrounded by 5–6 cells were found.

Remarks. Leaf margin with straight or hook-shaped teeth with acute apex and strongly cutinized and with cuticular ornamentation abaxial epidermis of leaf are characteristic of fossil poplar *Populus populina* (Brongniart) Knobloch.

In the respect of macromorphological and especially micromorphological features the most similar extant species are two contemporary species from the section *Leuce* Duby, *Populus alba* L. and *Populus tremula* L (Knobloch & Kvaček 1976).

Occurrence in the fossil floras of Poland. Middle Miocene – Kokoszyce (as *Populus latior* A. Br., Meyer 1919), Swoszowice (as cf. *Populus latior* A. Br., Ilinskaya 1962, 1964), Ruszów (Hummel 1983).

cf. ***Populus*** sp.

Fig. 5: 1; Pl. 6, fig. 1, Pl. 13, figs 2–4

Material. KRAM-P 244: B/3, B/7, B/12/I, B/16.

Macromorphology. Fragments of large leaves of probably suborbiculate or very wide ovate shape. Preserved fragments up to 9.3 cm long (presumably length of whole leaf 14–18 cm), and up to 7.5 cm wide (presumably width of whole leaf about 14 cm). Leaf margin not preserved. Venation pinnate. Primary vein straight, very stout (up to 0.2 cm wide!). Secondary veins diverging from primary vein at intervals of 1.7–3.5 cm and forming an angle of about 50–60° with it. Secondaries curve upward, produce numerous branches, lowermost veins produce pectinal veins. Intersecondary veins present, usually numerous. Tertiary venation composite intersecondary or weakly percurrent, forming an angle of about 90–110° with primary vein. About 6 tertiaries occur per 1 cm of the secondary vein length. Higher order venation orthogonal reticulate.

Micromorphology. Poorly preserved rests of adaxial (?) epidermis with cuticular reticulate ornamentation. Abaxial epidermis consists of frequently quadrangular, occasionally polygonal cells, 17.2–46.7 μm in size. Anticlinal cell walls minute bent or undulate. Stomata elliptic, narrow elliptic, occasionally wide elliptic, 22.1–34.4 μm in size. Outer stomatal ledge aperture narrow spindle-shaped or spindle-shaped, strongly cutinised, 17.2–29.5 μm long and 2.5–12.3 μm wide. On the abaxial epidermis traces of structures resembling papillae were found. On the fragment of undetermined epidermal layer rosettes of crystalloids of epicuticular wax were found.

Remarks. Fossil leaf fragments similar to members of genus *Populus*, but too poorly preserved to be unambiguously assigned to a specific taxon. *Populus balsamoides* Goeppert shows certain similarity to the discussed leaf remains (Kovar-Eder, pers. comm.).

Salix L.

Salix hausruckensis Kovar-Eder

Fig. 4: 2, 3; Pl. 4, figs 4, 6, Pl. 13, figs 5–7, Pl. 14, figs 1, 2

2001 *Salix hausruckensis* Kovar-Eder; Kovar-Eder & Wójcicki, pp. 229–232, Fig. 3: 10; pl. 2, figs 1–10, pl. 5, figs 1–8, pl. 6, fig. 12.

Material. KRAM-P 243: A/3/I, B/1 and B/2 (counterparts), B/3/I, B/7 and B/8 (counterparts), B/10, B/11, B/19, B/22, B/31, B/34; KRAM-P 244: B/23, B/36, C/11/I, C/22/I, C/26.

Macromorphology. Fragments of most probably coriaceous leaves, up to 7.7 cm long (presumably length of whole leaf 10 cm), and 6 cm wide (presumably width of whole leaf up to 8 cm). Leaf base cordate or slightly cordate, asymmetric. Leaf margin simple serrate, apical sides of teeth very short convex, basal sides long, acuminate, convex. Tooth apex usually rounded, occasionally acute. Secondary veins branches terminate in sinuses between teeth, this branches prolongate to the tooth apex. Venation brochidodromous. Primary vein more or less straight, rather stout (up to 0.10–0.15 cm wide). Secondary veins, considerably thinner than primary vein, run off primary vein at intervals of 0.5–1.6 cm and form an angle of about 55–80° (commonly 60–70°) with it. Secondaries curve upward, near leaf margin strongly, and run almost parallel to the leaf margin, interconnected in loops. Intersecondary veins almost always present, from few to numerous, reach half of the distance from the primary vein to leaf margin. Tertiary venation near primary vein composite intersecondary, towards leaf margin regularly percurrent, form an angle of 90–110° (commonly 100–110°) with primary vein. About 5 to 6 tertiaries occur per 1 cm of the secondary vein length. Higher order venation random reticulate, marginal ultimate venation most probably looped.

Micromorphology. Both epidermis strongly cutinised. Adaxial epidermis composed of isodiametric or slightly elongated cells, 8.6–39.4 μm in size. Anticlinal cell walls straight, occasionally rounded. Cuticle sometimes with striae ornamentation. Sometimes scarce layer of granular epicuticular wax is visible. Abaxial epidermis consists of isodiametric or slightly elongated cells, 11.0–34.5 μm in size. Anticlinal cell walls straight, rounded, exceptionally undulate. Almost always, often very abundant layer of granular epicuticular wax is visible on the cuticle of abaxial epidermis. Large stomata surrounded by radial striae. Leaves hypostomatic. Stomata predominantly brachyparacytic, besides anomocytic, anisocytic and, especially largest stomata, cyclocytic, narrow elliptic to elliptic, sometimes nearly rounded, 12.3–29.5 (37.0) μm in size. Outer stomatal ledge aperture from wide to narrow spindle-shaped, occasionally elliptic, strongly cutinized and variably-sized, (7.4) 8.6–25.8 (27.0) μm long and 2.5–12.3 (14.8) μm wide. On the abaxial epidermis, trichome bases, unicellular, elliptic to rounded, 6.1–12.3 (14.8) μm in size, surrounded by 4–8 cells were found. The trichomes on the abaxial epidermis could be completely absent to rather abundant (this case rather rare). On the adaxial epidermis the same type of trichomes were found, but very rare.

Remarks. Broad-leaved members of genus *Salix* are not very common in the Palaeogene and Neogene of Europe. Leaves of willow from Ruja match very well only with fossil *Salix hausruckensis* Kovar-Eder recently described by Kovar-Eder and Wójcicki (2001) from the Late Miocene flora from Hinterschlagen in Austria. Besides its broad leaves, it has typical structure of abaxial epidermis (stomata of mixed type: brachyparacytic, besides anomocytic, anisocytic, and cyclocytic). Due to lack of preserved petioles, presence of petiolar glands, characteristic of *Salix hausruckensis* (Kovar-Eder & Wójcicki op. cit.) could not be confirmed.

Kovar-Eder and Wójcicki (op. cit.) considered contemporary Florida Willow, *Salix floridana* Chapman as the most similar to the fossil *S. hausruckensis*. *S. floridana* is considered as subtropical, prequaternary relic (Kovar-Eder & Wójcicki 2001). Today it grows in swamps and along rivers in the southern Georgia and in the northern and central Florida occupying only limited few disjunctive areas being therefore placed on the list of endangered plants of USA (USDA, NRCS 2004).

Occurrence in the fossil floras of Poland. To date this species have not been reported from the Palaeogene and Neogene of Poland.

***Salix* cf. *kicktonii* Weyland**

Fig. 5: 3; Pl. 4, fig. 8

? 1934 *Salix kicktonii* Weyland, p. 42, pl. 2, fig. 1.

Material. KRAM-P 244: B/8/I, B/34/II.

Macromorphology. Fragments of elongated leaves, up to 7.0 cm long, and 2.8 cm wide. Leaf base cordate, asymmetric. Leaf margin on the preserved fragments entire, uneven. Petiole bent, about 1 cm long. Venation brochidodromous. Primary vein straight, stout. Secondary veins, considerably thinner than primary vein, run off primary vein at intervals of 0.5–0.7 cm. Secondaries curve upward, near leaf margin strongly (almost parallel to the leaf margin), interconnected in loops. Intersecondary veins present, distinct, frequently numerous. Tertiary venation near primary vein composite intersecondary, towards leaf margin regularly percurrent, form an angle of about 100–110° with primary vein.

Remarks. The characteristic cordate leaf base of the above described leaf allowed its comparison to *Salix kicktonii* Weyland. Yet, due to the poor state of preservation it could not be unambiguously assigned to this particular species. The another species of willow with cordate base, *S. holzeri* Kovar-Eder & Krainer differs from leaf from Ruja in having simple serrate leaf margin (Kovar-Eder & Krainer 1991). *Salix kicktonii* only rarely were reported from Palaeogene and Neogene floras of Europe and considered as riparian element (Kramer 1974 in: Belz & Mosbrugger 1994).

Occurrence in the fossil floras of Poland. To date similar leaf remains have not been reported from the Palaeogene and Neogene of Poland.

Salix varians* Goeppert *sensu lato

Fig. 4: 6; Pl. 4, figs 3, 5, Pl. 14, figs 3, 4

1855 *Salix varians* Goeppert, p. 26, pl. 19, figs 17, 18, pl. 20, fig. 1.

Material. KRAM-P 243: A/6/I, A/17, A/24, C/1, C/4/II, C/5/I, C/5/II, C/6, C/7, C/8, C/10, C/12/I, C/12/II, C/14; KRAM-P 244: B/4, B/9/I, B/14/II, B/17/I, B/35, B/40/I, B/41/I, B/42/II, B/46.

Macromorphology. Fragments of oblongate or lanceolate leaves, up to 7.8 cm long, and 1.2–2.8 cm wide. Leaf base mostly obtuse, sometimes decurrent. Leaves entire-margined (in this case occasionally revolute), uneven, undulate margin, or simple serrate. Apical sides of teeth very short concave, basal sides convex or acuminate. Tooth apex acute or rounded. Secondary veins branches terminate in sinuses between teeth. Petiole up to 1.3 cm long, bent. Venation brochidodromous. Primary vein straight, rather stout, up to 0.13 cm wide. Secondary veins, considerably thinner than primary vein, run off primary vein at intervals of 0.3–1.5 cm and form an angle of about 40–80° (90°, commonly 60–70°) with it, this angle decreases towards leaf apex. Secondaries curving upward, near leaf margin strongly (almost parallel to the leaf margin), interconnected in loops. Intersecondary veins present, frequently numerous, reach half of the distance from the primary vein to leaf margin. Tertiary venation near primary vein composite intersecondary, towards leaf margin regularly percurrent, forming angles of 100–110° (commonly 110°) with primary vein. Higher order venation reticulate.

Micromorphology. Adaxial epidermis composed of regular-shaped, isodiametric, occasionally elongated cells, polygonal, exceptionally quadrangular, 7.4–22.1 (entire-margined leaves) and 14.8–29.5 (serrate leaves) μm in size. Anticlinal cell walls predominately straight, occasionally rounded. Cuticle without or with striae ornamentation, sometimes epicuticular wax remnants were present. Abaxial epidermis consists of isodiametric or elongated cells, less regular in shape than adaxial epidermis, 9.8–27.0 μm in size. Anticlinal cell walls straight or rounded. Layer of granular epicuticular wax is usually visible on the cuticle of abaxial epidermis, occasionally very abundant and thus making the outlines of epidermal cells almost invisible. Leaves hypostomatic. Stomata almost always brachyparacytic, exceptionally cyclocytic or anisocytic (largest stomata), from narrow elliptic to nearly rounded, 12.3–29.5 μm in size. Outer stomatal ledge aperture from narrow to wide spindle-shaped, occasionally elliptic, strongly cutinized and dual, strongly variably-sized, 6.1–22.1 μm long and 2.5–12.3 μm wide. On the abaxial epidermis, trichome bases, unicellular, elliptic to rounded, 4.9–9.8 μm (entire-margined leaves) and 9.8–17.2 μm (in serrate leaves) in size, surrounded by 5–10 cells were found. On the adaxial epidermis the similar type of trichomes were found.

Remarks. The macro- and micromorphology of the leaf remains allowed their identification as *Salix varians* Goeppert (Knobloch & Kvaček 1976, Mai & Walther 1978, Belz & Mosbrugger 1994, Kovar-Eder & Meller 2003). This willow shows a considerable morphological variation in leaves (Krajewska 1998) and in the present author's opinion it is very probable that in fact *Salix varians* could constitute a collective species (*sensu lato*) of several taxa with similar morphology. Clearly, the differences in epidermis micromorphology are visible (see above).

Salix varians is a common species in the Palaeogene and Neogene floras of Europe from the Oligocene to the Pliocene (Krajewska op. cit.). It is usually compared with the extant Eurasian species of *S. fragilis* L. and *S. triandra* L. Similar structure of epidermis is reflected in the contemporary *S. bonplandiana* H. B. K. from Central America (Bůžek 1971, Krajewska 1998).

Occurrence in the fossil floras of Poland. Middle Miocene – Malczyce (as *Salicites dubius* Goepp., Goeppert 1852, Meyer 1919), Kokoszyce, Stróża (Kräusel 1920), Dobrzyń on the Vistula River (Kownas 1956), Stare Gliwice (Szafer 1961); Late Miocene – Sośnica (as *S. varians* Goepp., S. *wimmeriana* Goepp., *S. arcuata* Goepp., *S. acutissima* Goepp., *S. arguta* Goepp., Goeppert 1855, Meyer 1919), Bełchatów (Stuchlik et al. 1990), Gnojna (Krajewska 1998); Miocene – Trzebnica (Pax 1907), Ruprechtów (Kräusel 1920), Pierusza, Pogalewo Wielkie, Smogorzówek (Juhnke 1931).

***Salix* sp. 1**

Pl. 4, fig. 2, Pl. 14, figs 5, 6

Material. KRAM-P 243: A/5/II, A/11/I, A/14/I (counterpart to A/5/II).

Macromorphology. Leaf fragments, up to 5.5 cm long and 2.6 cm wide. Leaf margin simple serrate. Teeth 1.2–2.0 mm long and 0.3–0.4 mm high. Apical side of teeth concave, basal side convex or acuminate, rarely straight, tooth apex rounded or acute. Secondary veins or branches of them terminate in sinuses between teeth. Venation brochidodromous. Secondary veins curve upward, interconnected in loops, arranged at intervals 0.3–0.6 cm and form an angle of about 55° with primary vein. Intersecondary veins present, weakly developed. Tertiary venation weakly percurrent or composite intersecondary.

Micromorphology. Adaxial epidermis composed of polygonal, frequently slightly elongated cells, with mostly straight, occasionally rounded cell walls, 19.7–49.2 μm in size. Cuticle softly and densely striated. Abaxial epidermis composed of irregular-shaped cells, over the veins frequently elongated, with straight or rounded cell walls, 27.0–44.3 μm in size. Surface of cuticle with characteristic reticulate ornamentation. Leaves hypostomatic. Stomata usually brachyparacytic, occasionally anomocytic, elliptic, elongate elliptic, 14.8–33.0 μm in size. Stomata were often surrounded by striae perpendicular to them. Outer stomatal ledge aperture spindle-shaped or narrow spindle-shaped, 9.8–22.1 μm long and 2.5–7.4 (9.8) μm wide. On the abaxial epidermis occasionally were found unicellular, trichome bases, about 17 μm in diameter, surrounded by a few cells.

Remarks. Leaf margin, leaf venation and mainly paracytic stomata point to the genus *Salix* L. Epidermal structure suggests that it is possibly a new species of *Salix* but the poor state of preservation of leaf macromorphology in this case excluded any accurate comparison with fossil and contemporary taxa and the erection of a new species.

Salix sp.

Material. KRAM-P 243: A/21, B/3/III; KRAM-P 244: B/37/III, C/9/II.

Remarks. Fragments of willow leaves. Their poor state of preservation (no cuticular data) precludes an unequivocal assignment to the species level.

Juglandaceae Perleb

Pterocarya Kunth

Pterocarya paradisiaca (Unger) Ilinskaya

Fig. 5: 5; Pl. 4, fig. 7, Pl. 14, fig. 7, Pl. 15, fig. 1

1849 *Prunus paradisiaca* Unger, p. 7, pl. 14, fig. 22.
1897 *Pterocarya castaneifolia* (Goeppert) Schlechtendal, p. 22, pl. 5, figs 1–3b, pl. 6, figs 5–6.
1962 *Pterocarya paradisiaca* (Unger) Ilinskaya, p. 104.

Material. KRAM-P 243: D/2/III and D/3/III (counterparts).

Macromorphology. Almost completely preserved one narrow ovate leaflet, 7.3 cm long and 2.5 cm wide with attenuate apex. Leaflet margin serrate, only one tooth preserved with acute apex. Venation probably semicraspedodromous. Primary vein straight of moderate thickness. Secondary veins, preserved in 10 pairs, depart the primary vein at intervals of about 0.4–0.5 cm near leaflet base and 0.8–1.1 cm in the middle part of lamina, form an angle of 50° (near leaf base 60–70°) with the primary vein. Secondary veins upwardly curved and interconnected in loops. Only one intersecondary vein was found. Higher order venation reticulate.

Micromorphology. Adaxial epidermis composed of isodiametric or especially over the veins elongated cells, rather irregular, 12.3–36.9 μm in size, with straight or rounded anticlinal cell walls. Abaxial epidermis consists of mainly elongated cells, 19.7–44.3 μm in size, with undulate anticlinal cell walls. Cuticle apparently finely granulate. Leaflet hypostomatic. Stomata anomocytic, elliptic to wide elliptic, 19.7–41.8 μm in size. Outer stomatal ledge aperture elliptic, considerable cutinized and distinctly variably-sized, 9.8–24.6 μm long and 7.4–14.8 μm wide. On the abaxial epidermis scattered, glandular, peltate trichomes with unicellular (exceptionally two-celled), elliptic-rounded, strongly cutinised, 17.2–22.1 μm in diameter trichome bases were found. Only one preserved trichome shield have about 110 μm in diameter.

Remarks. The pattern of venation and peltate glandular trichomes with one-celled bases points to species *Pterocarya paradisiaca* (Unger) Ilinskaya. *Carya serrifolia* (Goeppert) Kräusel is macromorphologically similar to *P. paradisiaca* but differs in branched secondary veins having craspedodromous endings (comp. Hummel 1983, Manchester 1987). Leaflets of *Pterocarya* differ from those of another fossil genus *Cyclocarya* Ilinskaya, in their widely distributed teeth and the absence of looping at marginal tertiary veins as well as from leaflets of genus *Platycarya* in their semicraspedodromous venation (Manchester op. cit.).

Pterocarya paradisiaca is a frequent component of riparian communities in the Palaeogene and Neogene vegetation of Eurasia, known from the Late Oligocene to the Late Pliocene (Zastawniak et al. 1996).

The fossil species *Pterocarya paradisiaca* is similar to the contemporary *P. fraxinifolia* Spach (Ilinskaya 1968, Knobloch 1969), distributed in the Euxine-Hyrcanian forests of Anatolia, Transcaucasia and the southern shores of the Caspian Sea (Hyrcanian region) where it grows along river and stream valleys in riparian forest (Boratyński & Boratyńska

1975, Akhani & Salimian 2003). It is a character-species of *Pterocaryo-Alnetum glutinosae* riparian forests of the central Caspian coast being frequently associated with *Acer velutinum*, *Alnus glutinosa*, *Carpinus betulus*, *Fraxinus excelsior*, *Parrotia persica*, *Zelkova carpinifolia*, and (Rastin 1983).

Occurrence in the fossil floras of Poland. Early Miocene – Turów (Czeczott & Skirgiełło 1961); Middle Miocene – Swoszowice (Ilinskaya 1962), Stare Gliwice, Młyny, Stawiany, (Zastawniak 1980); Late Miocene – Sośnica (Meyer 1919) as *Pterocarya castaneifolia* (Goeppert) Schlecht., and Bełchatów (Stuchlik et al. 1990, Wójcicki & Zastawniak 1998, 2003, Worobiec 2003), Stare Bystre (Worobiec 1994); Miocene – Wołów (Kräusel 1920) as *Pterocarya castaneifolia*; Pliocene – Domański Wierch (Zastawniak 1972).

Fagaceae Dumortier

(?) **Castanea** Miller

„Castanea" kubinyii Kováts ex Ettingshausen sensu Knobloch & Z. Kvaček

Fig. 5: 9, 10; Pl. 5, fig. 3, Pl. 7, fig. 4, Pl. 15, fig. 2

1851 *Castanea kubinyi* Kováts, p. 178, nomen nudum.

1852 *Castanea kubinyi* Kováts; Ettingshausen, p. 6, pl. 1, fig. 12.

1976 *Castanea kubinyi* Kováts ex Ettingshausen; Knobloch & Kvaček, pp. 35–38, Fig. 13, 14, pl. 16, figs 7–9, pl. 18, figs 1, 4–10, pl. 23, figs 4, 6, 8–11, pl. 31, fig. 7.

Material. KRAM-P 243: D/1, D/4/II, D/7, D/8/II, D/9, D/10, D/12, D/15, D/16/I, D/16/II (counterpart to D/15), D/19, D/21, D/22, D/29, D/30/I, D/30/II, D/37, D/38/II, D/40/I.

Macromorphology. Fragments of leaves, up to 9.5 cm long and 6.4 cm wide. Leaf apex attenuate, occasionally acute, leaf base obtuse, sometimes nearly rounded. Leaf margin regularly simple serrate, teeth moderate or large, apical sides of teeth concave, basal sides concave, occasionally acuminate, tooth apex always acute, passing into a bristle which constitutes a spinose tooth termination reaching up to 0.1 cm long. Secondary veins terminate in tooth apex passing into a bristle. The longest preserved petiole is 0.8 cm long. Venation generally simple craspedodromous, only at the leaf base lowermost pair of secondary veins interconnected in loops. Primary vein mostly straight or slightly curved, of moderate thickness or thick. Up to 11 pairs of secondary veins preserved, depart primary vein at intervals 0.6–1.4 cm and form an angle of 35–60° with primary vein. Secondaries straight, rarely slightly curve upward, lowest secondaries first curved downward next upward and interconnected in loops. Tertiary venation percurrent, forming an angle of 120–140° (commonly 130°) with primary vein, 5 to 8 occur per 1 cm of the secondary vein length. Higher order venation orthogonal reticulate. Areoles well developed, 0.3–0.6 mm (commonly 0.45–0.50 mm). Veinlets present, frequently multiple branched.

Micromorphology. Adaxial epidermis composed of mostly quadrangular, sometimes polygonal, over the veins elongated cells, 17.2–35.7 μm in size. Anticlinal cell walls straight. Abaxial epidermis consists of variably shaped, frequently elongated cells, 17.2–36.9 μm in size. Anticlinal cell walls undulate, occasionally strongly undulate. Leaves hypostomatic. Stomata anomocytic, from elliptic to rounded, 18.5–27.0 μm (commonly 20–25 μm) in size. Outer stomatal ledge aperture narrow elliptic-oblongate, occasionally elliptic, exceptionally spindle-shaped, 7.4–14.8 μm long and 3.7–6.2 μm wide. Stomatal pore usually visible.

Remarks. The leaves have a leaf margins and venation pattern characteristic of several fossil species from the family Fagaceae such as *Castanea atavia* Unger, *C. gigas* (Goeppert) Ilinskaya, *C. kubinyii* Kováts ex Ettingshausen, *Quercus kubinyi* (Kováts ex Ettingshausen) Czeczott, and *Q. gigas* Goeppert emend. Walther & Zastawniak. Morphologically, they are identical to *Q. gigas*. However, they differ in their epidermal structure since *Q. gigas* has numerous stellate trichomes in abaxial epidermis, whereas leaves from Ruja completely lack them. This epidermal structure is typical for leaves of *„Castanea" kubinyii* Kováts ex Ettingshausen sensu Knobloch & Z. Kvaček (Knobloch & Kvaček 1976, Worobiec 2003). The authors share the opinion of others that it is not possible to distinguish fossil leaves representing the genera *Quercus* and *Castanea* solely on the basis of either their morphology or anatomy (Ferguson 1971, Knobloch & Kvaček 1976). Hence for this reason, it is unclear whether the leaves of „*Castanea*" *kubinyii* belong to oak or chestnut. Therefore the combination *Quercus kubinyi* (Kováts ex Ettingshausen) Czeczott proposed by Czeczottowa (1951) should not be considered as a valid one.

Leaves of „*Castanea*" *kubinyii* determined on the basis of anatomical studies were reported also from the Early Miocene of Wackersdorf (Knobloch & Kvaček 1976) and western Czech (Bůžek et al. 1996), the Miocene of southern Czech (Knobloch & Kvaček 1996), the Pliocene of Hungary (Hably & Kvaček 1997) and the Late Miocene of Hinterschlagen in Austria (Kovar-Eder & Wójcicki 2001). Fossil leaves described by Ferguson (1971) from Kreuzau (as form XIV, type *Castanea atavia* Unger), that were assigned by Knobloch and Kvaček (1976) to the species „*Castanea*" *kubinyii*, represent *Quercus gigas* (Worobiec 2003). The range of occurrence of „*Castanea*" *kubinyii* in the Neogene of Europe was certainly much larger because morphologically its leaves are identical with those of the genera *Castanea* and *Quercus* being therefore easily mistaken for other fossil leaf species of the family Fagaceae.

Occurrence in the fossil floras of Poland. Early Miocene of Bełchatów (Worobiec 1995, 2003).

Nyssaceae Dumortier

Nyssa Gronov. ex L.

Nyssa ornithobroma Unger

Pl. 5, fig. 1

1861 *Nyssa ornithobroma* Unger, p. 16, pl. 8, figs 15–18.

Material. KRAM-P 244: C/27: 8 endocarps.

Macromorphology. Endocarps of elliptic-ovate shape, 1.1–1.6 cm long and 0.5–0.8 cm wide. Surface of endocarp impression shows regular longitudinal parallel wrinkles.

Remarks. Characteristic shape of the endocarps indicates that these specimens belong to *Nyssa ornithobroma* Unger. This taxon was common in the Neogene of Central Europe. The occurrence of *Nyssa* L. indicates the presence of swamp vegetation (Worobiec 2003). *Nyssa ornithobroma* has no contemporary equivalent, showing only some similarity to *N. sinensis* Oliv. and *N. ogeche* Marsch. (Mai & Gregor 1982).

Occurrence in the fossil floras of Poland. Early Miocene – Bełchatów (Stuchlik et. al. 1990, Worobiec 1995, 2003); Miocene – Zielona Góra (Engelhardt 1892); Pliocene – Bełchatów (Wójcicki & Zastawniak 1998).

Ulmaceae Mirbel

Ulmus L.

Ulmus pseudopyramidalis Z. Kvaček & Hably

Fig. 5: 8; Pl. 5, fig. 6

1991 *Ulmus pseudopyramidalis* Z. Kvaček & Hably, p. 56, pl. 6, fig. 1.

Material. KRAM-P 244: B/22/II.

Macromorphology. Leaf 6.2 cm long and 3.3 cm wide with serrate margin. Teeth large. Both apical and basal sides of teeth mostly acuminate, occasionally convex. Tooth apex acute. Secondary vein enter the nearest tooth and terminate in tooth apex. Venation simple craspedodromous. Primary vein straight, of moderate thickness. Secondary veins preserved in 12 pairs, run off primary vein at intervals of 0.3–0.7 cm and form an angle of about 45–50° with it. Secondaries straight or slightly curve upward, frequently dichotomous branched, some branches terminates in sinuses between teeth. Tertiary venation apparently weakly percurrent of *Zelkova* type.

Remarks. Serrate leaf margin is characteristic of *Ulmus pseudopyramidalis* Z. Kvaček & Hably. The leaves of this taxon are distinctive for their "*Zelkova*"-like teeth, sometimes equipped with an additional tooth (Hably & Zastawniak 2001). When being compared to rather similar *Ulmus drepanodonta* Grubov, *U. pseudopyramidalis* differs in not having additional lobes in the upper part of the leaf (Hably & Zastawniak op. cit).

Occurrence in the fossil floras of Poland. Leaf of *Ulmus* sp. described from Miocene deposits of Nysa in Lower Silesia (Krajewska 2001) most probably belongs to the species *U. pseudopyramidalis.*

Ulmus cf. ***ruszovensis*** Hummel

Fig. 5: 2; Pl. 5, fig. 4, Pl. 15, fig. 3

? 1983 *Ulmus ruszovensis* Hummel, pp. 58–64, Fig. 24: 1–14, Fig. 25, pl. 36, figs 1–5a, pl. 37, figs 1–6a, pl. 38, figs 1–4a.

Material. KRAM-P 243: D/2/II and D/3/II (counterparts).

Macromorphology. Leaf fragment, 6.1 cm long and 2.6 cm wide with doubly serrate margin. Teeth characteristically upwardly curved. Both apical and basal sides of teeth acuminate, tooth apex acute. Secondary vein enter nearest tooth and terminate in tooth apex. Venation simple craspedodromous. Primary vein straight, of moderate thickness. Secondary veins, preserved in 11 pairs, run off primary vein at intervals of 0.4–0.7 cm and form an angle of about 50–60° with it. Secondaries first straight next slightly curve upward, frequently dichotomous branched, numerous branches terminate in teeth. Tertiary venation percurrent, forming with primary vein an angle of 150° near leaf base and 120° in the middle part of lamina, 9–10 tertiaries occur per 1 cm of the secondary vein length. Higher order venation more or less orthogonal reticulate.

Micromorphology. Abaxial epidermis composed of cells with rounded walls, about 9.8–17.2 μm in size. Stomata anomocytic, wide elliptic to rounded, 14.7–19.7 μm in size. Outer stomatal ledge aperture elliptic or wide elliptic, 6.1–9.8 μm long and 2.5–3.7 μm wide. Stomatal pore usually clearly visible. On the abaxial epidermis were found two-celled, two-segment, simple trichomes, 32 × 114 μm and numerous unicellular, elliptic to rounded trichome bases, 4.9–9.8 μm in diameter.

Remarks. The leaf is rather badly preserved. However, the characteristic structure of the leaf margin and network of tertiary venation both suggest that the leaf fragment probably belongs to the species *Ulmus ruszovensis* Hummel. According to Hummel (1983) fossil leaves of this taxon are most closely related to those of the contemporary *U. scabra* Mill.

Occurrence in the fossil floras of Poland. Pliocene – Ruszów (Hummel 1983).

Ulmus **sp.**

Fig. 5: 6, 7, 11; Pl. 5, figs 5, 7, Pl. 15, fig. 4, Pl. 16, fig. 1

Material. KRAM-P 243: D/14/I, D/18, D/25; KRAM-P 244: B/6/I, B/15/II, B/29, C/3/I, C/14.

Macromorphology. Leaf fragments with obtuse or cordate, asymmetric base. Leaf margin serrate. Teeth usually characteristically upwardly curved. Both apical and basal side of teeth mostly acuminate, occasionally convex, tooth apex acute. Secondary vein enter tooth and terminate in tooth apex. Venation simple craspedodromous. Primary vein straight, moderate thickness. Dense secondary veins run off primary vein at intervals of 0.3–0.9 (0.3–0.7) cm. Secondaries first straight, next slightly curved upward, near leaf margin strongly curved, frequently dichotomous branched. Tertiary venation percurrent, forming with primary vein an angle of 125–140°, 7–10 per 1 cm of the secondary vein length. Areoles about 0.35–0.50 mm in size, veinlets present, usually multiple branched.

Micromorphology. Adaxial epidermis composed of isodiametric and elongated cells, over the veins elongated, (11.0) 22.0–54.1 μm in size. Anticlinal cell walls predominately straight, occasionally rounded. Abaxial epidermis composed of isodiametric and elongated cells with straight and rounded anticlinal cell walls. Stomata anomocytic, elliptic to rounded, 20.9–32.0 μm in diameter. Outer stomatal ledge aperture distinct, uniformly and moderate cutinized, elliptic or elliptic-oblong, 9.8–17.2 μm long and 6.1–11.0 μm wide. On the abaxial epidermis unicellular trichome bases, 7.4–10.0 μm in diameter were found.

Remarks. The characteristic tooth shape of these leaf fragments allows to place them in *Ulmus* L. Nonetheless, the condition of their preservation does not allow more precise identification.

Zelkova Spach

Zelkova zelkovifolia (Unger) Bůžek & Kotlaba

Fig. 5: 4; Pl. 5, fig. 2

1841 *Ulmus zelkovaefolia* Unger, pp. 94–95, pl. 24, fig 7 pro parte, figs 9–12, pl. 26, fig. 7.

1963 *Zelkova zelkovaefolia* (Unger) Bůžek & Kotlaba; Kotlaba, pp. 59–62, pl. 3, figs 7, 8.

Material. KRAM-P 244: B/43.

Macromorphology. Very small fragment of one leaf with simply serrate margin. Teeth large, 0.5–0.7 cm long and 0.10–0.15 cm high, apical side of teeth short, acuminate, basal side convex or acuminate, tooth apex acute. Secondary veins or their branches terminate in tooth apex. Venation simple craspedodromous. Secondary veins, slightly curved upward, form an angle of about 40° with primary vein. Tertiary venation weakly percurrent.

Remarks. The specimen described has serrate margins with ”*Zelkova*”-like teeth, typical for leaves belonging to *Zelkova zelkovifolia* (Unger) Bůžek & Kotlaba. This species was a component of the European Palaeogene and Neogene riparian vegetation (comp. Kovar-Eder 2003) known from the Oligocene to the Plio-Pleistocene (Zastawniak et al. 1996). Among 5 extant species of the genus *Zelkova*, *Zelkova carpinifolia* (Pallas) K. Koch growing in the Euxino-Hyrcanian forests in Eastern Anatolia, Transcaucasia and the southern shores of the Caspian Sea in Lenkoran, and northern Iran (Kvavadze & Connor 2005) is considered to be the most similar to the fossil *Zelkova zelkovifolia.*

Occurrence in the fossil floras of Poland. Middle Miocene – Młyny (Zastawniak 1980), Late Miocene – Bełchatów (Stuchlik et al. 1990, Worobiec & Florjan 1997), Stare Bystre (Worobiec 1994), Late Miocene-Pliocene – Witów (Brud & Worobiec 2003), Pliocene – Domański Wierch (Zastawniak 1972). The other localities see Zastawniak (1972).

Ulmus L. vel ***Zelkova*** Spach

Material. KRAM-P 244: B/40/II.

Macromorphology. Only one leaf fragment with simple serrate margin has been preserved. Teeth large, characteristically upwardly curved. Both apical and basal sides of teeth acuminate, tooth apex acute. Secondary vein enter tooth and terminate in tooth apex. Venation simple craspedodromous. Primary vein straight, of moderate thickness. Secondary veins run off primary vein at intervals of 0.7–0.8 cm and form an angle of about 70° with it. Secondaries slightly curve upward. Tertiary venation weakly percurrent.

Remarks. Simple serrate leaf margin and large teeth both points to *Ulmus* and *Zelkova*. Upwardly curved teeth are rather more typical for *Ulmus* than for *Zelkova*.

Dicotyledones incertae sedis

Dicotylophyllum **sp. 1**

Pl. 16, figs 2, 3

Material. KRAM-P 243: B/12, C/2/I.

Macromorphology. Two leaf fragments, up to 5.0 cm. Secondary veins depart the primary vein at intervals of ca. 0.9–1.1 cm and form an angle of about 45–55° with it. Intersecondary veins present, weakly developed. Tertiary venation weakly percurrent or composite intersecondary.

Micromorphology. Adaxial epidermis composed of irregular-shaped cells, 22.1–56.6 μm in size. Anticlinal cell walls rounded or wide undulate. Cuticle granulate. Abaxial epidermis consists of isodiametric or elongated cells, 12.3–24.6 μm in size. Anticlinal cell walls straight or rounded. Leaves hypostomatic. Stomata anomocytic, occasionally brachyparacytic, wide elliptic to rounded, 13.5–19.7 μm in size. Outer stomatal ledge aperture wide elliptic to spindle-shaped, 6.1–14.8 μm long and 3.7–9.8 μm wide. On the abaxial epidermis, solitary, unbranched trichomes, about 100 μm in size with unicellular, rounded to elliptic trichome bases (10–12 μm in size) were found.

Remarks. The leaf under discussion shows certain similarity to leaves of the genus *Acer*. The state of preservation precludes further determination of its taxonomical position.

Dicotylophyllum **sp. 2**

Fig. 6: 4; Pl. 5, fig. 8, Pl. 16, fig. 4

Material. KRAM-P 244: C/3/II.

Macromorphology. Leaf fragment, with serrate margin. Apical side of teeth concave or straight, basal side convex or straight, tooth apex acute. Secondary veins terminate in tooth apex. Venation actinodromous, marginal. Primary vein branched into 5 branches. Tertiary venation percurrent. Higher order venation reticulate. Areoles well developed.

Micromorphology. Adaxial epidermis composed of isodiametric, occasionally elongated cells, 22.1–56.6 μm in size, over the veins cell strongly elongated. Anticlinal cell walls straight, sometimes fine-bent or fine-undulate. Cuticle striate or undulate. Abaxial epidermis consists of isodiametric or slightly elongated cells, 14.8–34.4 μm in size. Cuticle seems to be rippled. Leaves hypostomatic. Stomata cyclocytic and anomocytic, elliptic to wide elliptic, 17.2–24.6 μm in size. Outer stomatal ledge aperture spindle-shaped, 8.6–14.8 μm long and 3.7–7.4 μm wide. On the abaxial epidermis, multicellular (about 4–celled) trichome bases were found, 19.7–22.1 μm in size. Peltate trichome shield about 55.0–60.0 μm in diameter.

Remarks. The described leaf fragment is preserved in such a poor state that its systematic position is unknown.

***Dicotylophyllum* sp. 3**

Pl. 16, fig. 5

Material. KRAM-P 244: C/8/III.

Macromorphology. Fragment of leaf of unknown shape, 6.5 cm long and 2.5 cm wide.

Micromorphology. Abaxial epidermis consists of cells with straight and thin anticlinal cell walls. Stomata elliptic, 17.2–27.0 μm in size. Outer stomatal ledge aperture spindle-shaped, distinctly cutinised and often dual, on the poles acuminate, 13.5–22.1 μm long and 4.9–7.4 μm wide.

Remarks. The described leaf fragment has been preserved in such a poor state that its systematic position is unknown.

***Dicotylophyllum* sp. 4**

Fig. 6: 3

Material. KRAM-P 243: D/40.

Macromorphology. Fragment of entire-margined leaf, 4.5 cm long and 3.7 cm wide. Venation brochidodromous. Primary vein straight. Secondary veins run off primary vein at intervals of about 1.1 cm and form an angle of 60–70° with it. Secondaries evenly curved upward and interconnected in loops. Intersecondary veins present, distinct. Tertiary venation composite intersecondary or weakly percurrent (in case of absence of intersecondary veins).

Remarks. The described leaf fragment has been preserved in such a poor state that its systematic position is unknown.

Dicotyledones indeterminatae

Fig. 6: 5; Pl. 6, fig. 4

Material. KRAM-P 243: B/6, C/4/I, D/17, D/28/I, D/31; KRAM-P 244: B/24, B/28/II, B/30, B/41/II, C/3/III, C/17.

Remarks. The described dicotyledonous leaf fragments have been preserved in such a poor state that determination of their systematic position is completely impossible.

Monocotyledones

Poaceae (R. Brown) Barnhart

***Phragmites* Adanson**

***Phragmites oeningensis* A. Braun**

Pl. 6, fig. 6, Pl. 7, fig. 5, Pl. 16, fig. 6

1851 *Phragmites oeningensis* A. Braun; Stizenberger, p. 75.

1855 *Phragmites oeningensis* A. Braun; Heer, p. 64, pl. 22, fig. 5, pl. 24, pl. 27, fig. 2b, pl. 29, fig. 3e.

Material. KRAM-P 243: A/1, C/13; KRAM-P 244: B/9/II, B/26/I, B/34/III.

Macromorphology. Fragments of linear leaves, up to 7.4 cm long and 1.8–3.9 cm wide (presumably width of whole leaf 3–5 cm). Venation parallelodromous. Midvein distinct. On both sides of the midvein vein lie 10–14 less distinct lateral veins spaced 1.2–2.3 mm apart, between them lie 4 to 7 (most commonly 5 to 7) delicate, third order parallel veins, regularly spaced 0.2–0.3 mm apart. Cross (transverse) veins absent. The arrangement of parallel veins in the leaves of *Phragmites oeningensis* can be expressed by the formula AcBc (Hickey and Peterson 1978).

Remarks. Parallel venation with a marked midvein and without cross veins is characteristic for the fossil species *Phragmites oeningensis* A. Braun. It was common in the Palaeogene and Neogene of Europe. Cosmopolitan *Ph. communis* Trin. is its recent equivalent (Krajewska 1998).

Occurrence in the fossil floras of Poland. Middle Miocene – Konin (Raniecka-Bobrowska 1954), Dobrzyń on the Vistula River (Kownas 1956), Swoszowice (Ilinskaya 1964), Stawiany (Zastawniak 1980); Late

Miocene – Gnojna (Krajewska 1998); Miocene – Kunice Żarskie (Engelhardt 1877), Zielona Góra (Engelhardt 1887, 1892).

Zingiberaceae Martynov

Zingiberoideophyllum Kräusel & Weyland

Zingiberoideophyllum liblarense Kräusel & Weyland

Pl. 4, fig. 9, Pl. 7, fig. 6, Pl. 17, figs 2, 3

1954 *Zingiberoideophyllum liblarense* Kräusel & Weyland, pp. 120, 121, pl. 23, figs 1–4.

Material. KRAM-P 244: C/1/II and C/2/I (counterparts), C/21.

Macromorphology. Fragments of broad and elongate leaves up 4 cm wide. Venation parallelodromous. No midrib visible, more or less uniform veins are spaced 0.2–0.3 mm apart. Very numerous cross (transverse) veins connect adjacent parallel veins. The cross veins are oriented mostly perpendicular to parallel veins and form with them square or short rectangular, variably-sized areoles. Numerous black spots are visible on the compression of leaf, most probably represent remnants of secretory cells content.

Micromorphology. Adaxial epidermis consist of irregular-rectangular, diversified cells: cells parallel to the long axis of leaf are 16.0–52.0 µm long and cells perpendicular to long axis of leaf are 11.0–22.1 µm long. Anticlinal cell walls rounded-undulate. Abaxial epidermis consist of usually elongated, irregular-rectangular, diversified cells: between stomatal bands cells are longer than inside stomatal bands. Arrangement of cells more or less linear, size of cells 15.0–59.0 µm. Anticlinal cell walls rounded or wide undulate. Leaves hypostomatic. Stomata arranged in stomatal bands, parallel to the leaf venation, composed of 3–5 rows of stomata between each vein, commonly less than 10 stomata occur on the area of each areole. Stomata tetracytic, wide elliptic to rounded, 24.6–36.9 µm in diameter. Longer axis of stomata frequently perpendicular to the axis of outer stomatal ledge (exceptionally case of stomata) and to the leaf venation. Outer stomatal ledge aperture spindle-shaped or narrow spindle-shaped, thickened, strongly cutinized, 17.2–24.6 µm long and 4.9–12.3 µm wide, whole outer stomatal ledge is about 32.0–35.0 µm long. Sometimes outer stomatal ledge aperture is surrounded by cuticular crest. Inside mesophyll visible remnants of brown content of secretory cells.

Remarks. Venation pattern and epidermal structure of the specimens are characteristic of the species *Zingiberoideophyllum liblarense*. The leaves of this taxon are characterized by tetracytic stomata and the presence of hypodermis and secretory cells (Kräusel & Weyland 1954). Leaves of *Zingiberoideophyllum liblarense* in the Ruja deposits in the same horizon are accompanied by seeds of *Spirematospermum wetzleri* (Heer) Chandler from the family Zingiberaceae. In the European Neogene floras both species were frequently found together (Knobloch & Kvaček 1976, Gregor 1989 – Schwandorf). It is very probable that in fact both morphotaxa represent remains of the same plant species.

Occurrence in the fossil floras of Poland. Late Miocene – Bełchatów (Worobiec & Lesiak 1998). Other representatives of the family Zingiberaceae were found in the Middle Miocene deposits of Dobrzyń upon the river Vistula (Kownas 1956, 1959).

cf. ***Zingiberoideophyllum liblarense*** Kräusel & Weyland

Material. KRAM-P 243: A/26/II.

Remarks. Leaf fragment similar to *Zingiberoideophyllum liblarense*. The state of preservation (no cuticular data) precludes unequivocal assignment to this particular species.

Spirematospermum M. E. J. Chandler ex F. Kirchheimer

Spirematospennum wetzleri (Heer) Chandler

Pl. 4, fig. 1

1859 *Gardenia wetzleri* Heer, p. 192, pl. 141, figs 81–103.

1925 *Spirematospermum wetzleri* Chandler, p. 17, pl. 1, figs 8a–c.

Material. KRAM-P 244: C/28: 2 seeds.

Macromorphology. Seeds 0.6–0.7 cm long and about 0.3 cm wide, characteristically irregularly elongate in shape and irregularly wrinkled due to squeezing by neighbouring seeds in fruit. Testa with dense oblique striation on surface.

Remarks. This is an extinct palaeotropical species, common in the Palaeogene and Neogene deposits of the northern hemisphere (Friis 1988, Mai & Walther 1991). Fruits and seeds of *Spirematospermum wetzleri* (Heer) Chandler are found from the Eocene to the Pliocene (in the Pliocene it is considered as a relic), mainly in the Oligocene and Miocene deposits (Zastawniak et al. 1996).

Spirematospennum is considered to be a component of bottomland vegetation, as indicated by its occurrence in lignites from Europe and North America (Friis 1988). This fossil species is in the opinion of Friedrich and Koch (1970) related to the contemporary Indo-China *Cenolophon oxymitrum* (Schumann) Holttum from the family Zingiberaceae.

Occurrence in the fossil floras of Poland. Middle Miocene – Nowogród Bobrzański (Kräusel 1920), Rypin (Łańcucka-Środoniowa 1957), Dobrzyń on the Vistula River (Kownas 1959), Chyżne, Jabłonka (Łańcucka-Środoniowa 1965); Late Miocene – Bełchatów (Stuchlik et al. 1990, Worobiec & Lesiak 1998); Late Miocene-Pliocene – Witów (Brud & Worobiec 2003).

Hydrocharitaceae Jussieu gen. indet.

Pl. 7, fig. 7, Pl. 17, fig. 4, Pl. 18, figs 1–3

Material. KRAM-P 244: C/19/I, C/24/I, C/24/II.

Macromorphology. Very small fragments of leaves with parallel venation. Cross (transverse) veins connect adjacent parallel veins. Leaf margin minute serrate with characteristic prickles (see Ancibor 1979). Prickles spine-shaped, bent and of variable size: 0.15–0.22; 0.23–0.28; 0.59 mm long and 0.12–0.2; 0.15–0.22; 0.44 mm high, probably due to taxonomical differences (probably different taxa or even genera). Prickles sometimes are present outside margin, on the surface of leaves.

Micromorphology. Leaves without stomata. Both sides of epidermis seem to be uniform. They consist of rectangular or polygonal, sometimes more elongated cells, 64.0–158.0 and 191.0–345.0 μm long. Anticlinal cell walls almost straight, occasionally rounded. Longer axis of cells frequently parallel, occasionally perpendicular to the leaf venation.

Remarks. These remains most probably belong to the family Hydrocharitaceae as can be inferred from the presence of prickle hairs on leaf margins (Ancibor 1979, Kvaček 2003). Most probably there are remains of two different taxa (two species of the same genus?), but due to scarcity of remains, the erection of new taxa is not yet possible. They are representatives of taxa with leaves completely submerged in water as could be inferred from the complete absence of stomata. The presence of prickles on leaves excludes the genera *Hydrocharis* L. and *Limnobium* Rich. (Ancibor op. cit). The combination of macro- and micromorphological features suggest other genera *Blyxa* Noronha ex Thouars, *Ottelia* Pers., *Stratiotes* L., and *Vallisneria* L.

Occurrence in the fossil floras of Poland. Compressions of leaves of *Stratiotes* were found in Konin (Raniecka-Bobrowska 1954) and Bełchatów (Stuchlik et al. 1990).

Monocotyledones incertae sedis

Cyperacites Schimper sensu Z. Kvaček & Hurník

Cyperacites sp.

Pl. 7, fig. 8, Pl. 17, fig. 1

1870-1872 *Cyperacites* Schimper, p. 415.

2000 *Cyperacites* Schimper sensu Z. Kvaček & Hurník, p. 22, Fig. 3: 17, Fig. 5: 3, pl. 12, figs 4, 5.

Material. KRAM-P 243: B/3/II, C/2/II, C/3/II, C/11, D/4/III, D/28/II, D/35.

Macromorphology. Fragments of linear leaves, up to 3.4 cm long and up to 1.5 cm wide, entire-margined (in one specimen leaf margin seems to be slightly revolute). Venation parallelodromous. Distinct primary midvein. On both sides of the primary vein lie less distinct lateral veins, spaced 0.3–0.5 (0.7) mm apart, and about 0.1–0.2 mm thick. Cross (transverse) veins connect adjacent parallel veins. The cross veins are oriented perpendicular to them forming elongated rectangles, 0.8–2.5 mm (usually 1.0–1.6 mm) long. The arrangement of parallel veins of these leaves can be expressed by the formula Ab (Hickey & Peterson 1978).

Micromorphology. Small fragments of delicate cuticle were obtained. They show dense traces of probably silica bodies or papillae, 14.7–17.2 μm in size, arranged transversely to the long axis of epidermal cells. Surface of cuticle granular.

Remarks. Kvaček and Hurník (2000) employed the genus name *Cyperacites* Schimper in broad sense as to include fossil monocots previously assigned to the species representing genera *Poacites* Brongniart, *Cyperites* Lindley & Hutton and *Monocotylophyllum* Reid & Chandler (invalid name). In the opinion of Kvaček and Hurník (op. cit.) attempts of previous researches to recognize among fossil monocotyledons genera and species have failed. However, macro- and micromorphological (if possible) analysis of such leaves can bring some information on monocot diversity.

Occurrence in the fossil floras of Poland. Similar type of monocotyledon remains (*Cyperacites*) were reported from the Middle Miocene locality of Młyny (Zastawniak 1980) and the Pliocene of Domański Wierch (Zastawniak 1972).

Varipilicutis Schneider

cf. ***Varipilicutis liblarensis*** (Kräusel & Weyland) Schneider

Pl. 18, fig. 4

? 1954 *Dioscoreophyllum* (*Dioscorea*?) *liblarense* Kräusel & Weyland, Fig. 6, pl. 21, figs 5–7, pl. 22, figs 1–2.

? 1963 *Dioscorea liblarensis* (Kräusel & Weyland) Peters, Fig. 4, non 5, pl. 5, figs 28, 29, non 30, 31.

? 1969 *Varipilicutis liblarensis* (Kräusel & Weyland) Schneider, pl. 9, fig 1.

Material. KRAM-P 244: C/2/II.

Macromorphology. Fragment of very poorly preserved leaf, ca. 4 cm long. Venation parallelodromous. No midrib is visible preserved, more or less uniform veins are spaced 1.0–1.5 mm apart. Cross (transverse) veins connect adjacent parallel veins. The cross veins are oriented mostly oblique to them and form rhomboidal, well developed, variably-sized (0.15–0.40 mm) areole.

Micromorphology. Leaves generally amphistomatic. Adaxial epidermis consist of isodiametric and elongated, usually polygonal cells, 24.6–83.6 (108) μm in size. Over the veins cells are strongly elongated and narrow. Anticlinal cell walls almost always straight, thick. Surface of cuticle bear ornamentation in form of thick "folds". On the adaxial epidermis hardly ever could be found paracytic stomata. Abaxial epidermis consist of isodiametric or elongated, usually polygonal cells, 46.7–73.8 μm in size. Over the veins cells elongated. Anticlinal cell walls almost always straight. Surface of cuticle bear very distinct ornamentation in form of filigree-tubercle or papillae. Stomata paracytic, elliptic, 39.4–54.1 μm in size. Stomata oriented – longer axis of stomata parallel to the leaf venation. Surface of subsidiary cells frequently shows less distinct ornamentation than remaining cells of abaxial epidermis. Outer stomatal ledge aperture regularly spindle-shaped, strongly cutinised, 29.5–39.4 μm long and 9.8–17.2 μm wide.

Remarks. The leaf remains in question resemble fossil leaves of *Varipilicutis liblarensis* (Kräusel & Weyland) Schneider found in Miocene lignite deposits from Nochten in Lusatia, Germany (Schneider 2004). At first this type of fossils were as ascribed to *Dioscoreophyllum liblarense* Kräusel & Weyland (Kräusel & Weyland 1954). Schneider (op. cit.) discussed micromorphological features of *Varipilicutis liblarensis* and rejected its inclusion in the family Dioscoreaceae.

Occurrence in the fossil floras of Poland. Leaf remains of this type have not been reported from the Palaeogene and Neogene of Poland. Poorly preserved fossil leaf cuticle described as *Dioscorea* sp. from the Early Miocene deposits of Turów (Juchniewicz 1966) differs markedly from *Varipilicutis*-like remains from Ruja and is surely not related to them.

Incertae sedis

Pl. 6, fig. 5

Material. KRAM-P 243: B/5, B/25; KRAM-P 244: B/1, B/11, B/25/II (counterpart to B/11).

Remarks. Systematic position of these plant remains is unknown.

RESULTS OF INVESTIGATIONS ON PLANT MACROREMAINS

As the result of investigation of 280 specimens of plant macroremains from the two cores, 35 taxa from genera *Acer*, *Alnus*, *Byttneriophyllum*, *Carpinus*, *“Castanea”*, *Cercidiphyllum*, *Cyperacites*, *Dicotylophyllum*, *„Ficus”*, *Glyptostrobus*, *Myrica*, *Nyssa*, *Osmunda*, *Phragmites*, *Populus*, *Pterocarya*, *Salix*, *Sequoia*, *Spirematospermum*, *Ulmus*, *Varipilicutis*, *Woodwardia*, *Zelkova*, and *Zingiberoideophyllum* representing families Betulaceae, Blechnaceae, Cercidiphyllaceae, Cupressaceae, Fagaceae, Hydrocharitaceae, Juglandaceae, Malvaceae, Myricaceae, Nyssaceae, Osmundaceae, Poaceae, Salicaceae, Sapindaceae, Ulmaceae, and Zingiberaceae were found.

Taxonomic diversity of plant assemblages from the cores is highly variable: from one taxon in horizon 77–78 m (borehole 97/73) to 25 taxa in underneath lying horizon 102–105 m representing the same borehole. Taxonomical composition of plant assemblages found in the investigated cores is presented in Tables 1 and 2.

Five new taxa to the Polish Palaeogene and Neogene were reported. These include *Salix hausruckensis* Kovar-Eder, *Salix* cf. *kicktonii* Weyland, *Salix* sp. 1, *Ulmus pseudopyramidalis* Z. Kvaček & Hably, and cf. *Varipilicutis liblarensis* (Kräusel & Weyland) Schneider. Detailed documentation (description and illustration) of leaflet epidermis of *Osmunda parschlugiana* (Unger) Andreánszky and leaf remains of Hydrocharitaceae was completed.

TAPHONOMY

BIOSTRATINOMY

Plant macroremains (mainly leaves) were preserved as dispersed in rock as well as in the form of accumulated fossil leaf litter composed of humified fragments of leaf blades, branches of coniferous trees (almost exclusively twigs of *Glyptostrobus*), and very rarely with the addition of diaspores. As it concerns fine-grained structure of deposits with fossil plants (silts and clays) it can be deduced that plant remains were deposited in water reservoirs with stagnant or slow-flowing water. Most probably these reservoirs could have been represented by meander cutoffs of meandering rivers (oxbow lakes) or abandoned channels of braided rivers on floodplains. Flood waters periodically delivered detritic material together with immediately buried plant macroremains that accumulated on the reservoir bottom (tanatocoenoses) leading to their direct preservation by preventing extensive decay or complete decomposition. To such sedimentary reservoirs dead plant macroremains were transported by wind, or carried by rainfall and flood waters. Tanatocoenoses of macroremains were parautochtonous (comp. Gastaldo et al. 1996), as confirmed by the dominance of taxa characteristic of azonal vegetation (swamp and riparian). Mesophytic plant remains are very scarce. It could indicate that the floodplain in question was very flat and/or very wide, and that the sedimentary reservoir was situated at a great distance from any elevated and drier river terraces being typically covered with mesophytic vegetation. This reasoning is also confirmed by palynological investigations. Analysis of sporomorphs from samples taken from horizons with plant macroremains revealed low frequency of pollen grains of mesophytic taxa with simultaneous dominance of swamp and riparian elements in pollen spectra. Occurrence of zygospores of Zygnemataceae algae (Tab. 3) also points to the presence of shallow, stagnant waters (van Geel et al. 1989). Fossil leaf litter could result from very rapid accumulation of dead plant parts that represented either surrounding vegetation close to such abandoned channels, or seasonal leaf fall, or much rarer storm destructions of trees leading to their subsequent transportation by rainfall or flood waters into sedimentary reservoirs, and subsequent mass deposition on the bottom.

FOSSIL DIAGENESIS

Plant macroremains are preserved mostly as slightly carbonized (humified) specimens, leaves partly as impressions (some of them as adpressions with badly preserved remnants of carbonized tissue). The blades are often fragmented and deformed due to compaction and deformation of the deposits. The preservation state of macroremains was generally very good and in case of leaves and coniferous shoots it even enabled isolation of fossil cuticles. However, in some of fossil horizons, leaf compressions found dispersed in sediment were poorly preserved. It seems to suggest that degree of leaf decay in this horizons was considerably high before their burial in sediment or that after their burial leaf remains were exposed to temporal access of oxygen penetrating such deposits, especially in the initial stages of diagenetic changes of taphocoenosis resulting in formation of oryctocoenosis.

Table 3. Results of palynological analysis of the samples from horizons with plant macroremains from boreholes Komorniki 97/72 (KRAM-P 243) and Komorniki 97/73 (KRAM-P 244). **P** - palaeotropical element: **P1** – tropical, **P2**- subtropical; **A** - arctotertiary element: **A1** – warm temperate, **A2** – cool temperate

	Taxon	Element	Labels of horizons with plant macroremains									
			244/A	243/A	244/B	244/B	243/B	243/C	244/C	243/D	243/E	244/D
1	*Baculatisporites* sp., *Rugulatisporites* sp. (*Osmunda*)	A1	10	2	1	2	1		1			5
1	*Laevigatosporites* sp. sp. (Polypodiaceae/Davalliaceae)	P/A	6	14	1	232	392	2		2		27
1	*Leiotriletes* sp. (Schizaeaceae/Cyatheaceae)	P										1
1	*Stereisporites* sp. (*Sphagnum*)	A1				2						
2	*Abiespollenites* sp. (*Abies*)	A		2					1	1	4	1
2	*Inaperturopollenites* sp. sp. (Taxodiaceae/Cupressaceae)	A1	23	48	33	8	100	11	55	1	59	223
2	*Keteleeriapollenites dubius* (Chlonova) Słodkowska (*Keteleeria*)	A1					1					2
2	*Piceapollis* sp. sp. (*Picea*)	A	1	1		1		1			1	4
2	*Pinus haploxylon* type/*Cathayapollis* sp.	A1	5	6	5	15	12	5	3	1	17	65
2	*Pinuspollenites* sp. *Pinus sylvestris* type	A	10	25	15	16	30	4	9	3	37	74
2	*Sciadopityspollenites* sp. sp. (*Sciadopitys*)	A1	1				1					2
2	*Sequoiapollenites* sp. sp. (*Sequoia/Cryptomeria*?)	A1	1	5		2		1	1		262	2
2	*Zonalapollenites* sp. sp. (*Tsuga*)	A				1	1		1	1	2	5
3	*Aceripollenites* sp. (*Acer*)	A1										1
3	*Alnipollenites verus* Potonié ex Potonié (*Alnus*)	A1	24		12	3	104		19	1	8	39
3	*Araliaceoipollenites edmundi* (Potonié) Potonié ex Potonié (Araliaceae)	P2									5	
3	*Araliaceoipollenites euphorii* (Potonié) Potonié ex Potonié (Araliaceae)	P2									1	1
3	*Arecipites* sp. (Arecaceae)	P2									1	
3	*Artemisiaepollenites sellularis* Nagy (Asteraceae-*Artemisia*)	A1		1								
3	*Betulaepollenites betuloides* (Pflug) Nagy (*Betula*)	A1				3	1	3	2		3	1
3	*Caprifoliipites sambucoides* Nagy (*Sambucus*)	A1									2	
3	*Carpinipites carpinoides* (Pflug) Nagy (*Carpinus*)	A1				1	1				1	
3	*Caryapollenites simplex* (Potonié) Raatz (*Carya*)	A1			1			2			6	4
3	*Castaneoideaepollis oviformis* (Potonié) Grabowska (*Castanea/Castanopsis*)	P2				1					5	
3	*Castaneoideaepollis pusillus* (Potonié) Grabowska (*Castanea/Castanopsis*)	P2						2			7	
3	*Celtipollenites verus* (Raatz) Ziembińska-Tworzydło (*Celtis*)	A1	1	2	1		2					30
3	*Cercidiphyllites minimireticulatus* (Trevisan) Ziembińska-Tworzydło (*Cercidiphyllum*)	A1										4
3	*Cornaceaepollis major* (Stuchlik) Stuchlik (Cornaceae-Cornoideae)	P2									1	
3	*Cornaceaepollis satzveyensis* (Pflug) Ziembińska-Tworzydło (Cornaceae-Mastixioideae)	P1							1			
3	*Diervillapollenites megaspinosus* Doktorowicz-Hrebnicka (*Diervilla/Weigela*)	A2									2	
3	*Engelhardtioipollenites punctatus* (Potonié) Potonié ex Potonié (*Engelhardtia*)	P2										3
3	*Ericipites ericius* (Potonié) Potonié + *E. callidus* (Potonié) Krutzsch (*Erica* + *Calluna*)	A					1				2	
3	*Ericipites roboreus* (Potonié) Krutzsch (*Rhododendron/ Arbutus unedo*)	A		1							5	
3	*Eucommioipollenites eucommius* (Planderova) Ziembińska-Tworzydło (*Eucommia*)	A1				1					1	
3	*Faguspollenites verus* Raatz ex Potonié (*Fagus*)	A2			1				2		3	
3	*Ilexpollenites iliacus* (Potonié) Thiergart ex Potonié + *I. margaritatus* (Potonié) Raatz ex Potonié (*Ilex*)	P2, P2						1	1		20	1

Table. 3. Continued

	Taxon	Element	Labels of horizons with plant macroremains									
			244/A	243/A	244/B	244/B	243/B	243/C	244/C	243/D	243/E	244/D
3	*Liquidambarpollenites* sp. (*Liquidambar*)	A1				1						2
3	*Meliapollis* sp. (Meliaceae)	P1									1	
3	*Myricipites* sp. (*Myrica*)	P2		4	3	1		2			4	1
3	*Nympheapollenites* sp. (Nympheaceae)	A2				1						
3	*Nyssapollenites* sp. (*Nyssa*)	A1		1		1					21	9
3	*Oleoidearumpollenites microreticulatus* (Pflug & Thomson) Ziembińska-Tworzydło (Oleaceae)	A1									1	
3	*Oleoidearumpollenites* sp. 1 (*Fraxinus*)	A1				1?					1	
3	*Oleoidearumpollenites* sp. 2 (Oleaceae)	A1	1						1			1
3	*Platycaryapollenites* sp. (*Platycarya*)	P2					1?				1	4
3	*Potamogeton* type	A		1		2						
3	*Pterocaryapollenites stellatus* (Potonié) Thiergart (*Pterocarya*)	A1			1						1	1
3	*Quercoidites henrici* (Potonié) Potonié, Thomson & Thiergart (Quercoideae)	P2									15	6
3	*Quercoidites* sp. (*Quercus*)	A1	1?		2	3	4		1		10	14
3	Rutaceae? type	?				1						
3	*Salixipollenites* sp. (*Salix*)	A2	1	4	51	2	15	22	3		5	
3	*Sparganiaceaepollenites* sp. (*Sparganium*)	A				1				1	9	
3	*Spinulaepollis arceuthobioides* Krutzsch (Loranthaceae-*Arceuthobium*)	A1									1	
3	*Tricolporopollenites quisqualis* (Potonié) Krutzsch (Fabales)	P2										4
3	*Tricolporopollenites retiformis* (Pflug & Thomson) Krutzsch	A1									1	
3	*Tricolporopollenites exactus* (Potonié) Grabowska (Cyrillaceae/Clethraceae)	P2		1	1	1	1				27	2
3	*Tricolporopollenites fallax* (Potonié) Krutzsch (Fabales)	P2			1		1				10	1
3	*Tricolporopollenites liblarensis* (Thomson) Grabowska (Fabales)	P2									17	5
3	*Tricolporopollenites marcodurensis* Pflug & Thomson (Vitaceae?-*Parthenocissus*?)	P1									3	
3	*Tricolporopollenites pseudocingulum* (Potonié) Thomson & Pflug (Fagaceae-Fagoideae)	P2	1		3		4		1		42	9
3	*Tricolporopollenites* type Rosaceae	A1									1	1
3	*Tricolporopollenites* type *Rumex*	A		2								
3	*Triporopollenites urticoides* Nagy (*Urtica*)	A		1								
3	*Ulmipollenites undulosus* Wolff + *Zelkovaepollenites potoniei* Nagy (*Ulmus*/*Zelkova*)	A2, A1		2	1	1					3	3
3	*Vitispollenites* sp. (*Vitis*)	A1		1	1							1?
4	Dinophlagellate cysts	X						1				
4	*Ovoidites* sp. (Zygnemataceae)	X			4						1	
4	*Sigmopollis pseudosetarius* (Weyland & Pflug) Krutzsch & Pacltová (Cyanophyta?, Chlorophyta?)	X			4							
4	*Sigmopollis punctatus* Krutzsch & Pacltová (Cyanophyta?, Chlorophyta?)	X			2							
4	*Sigmopollis* sp. (Cyanophyta?, Chlorophyta?)	X										3
4	*Tetraporina* sp. (Zygnemataceae)	X			1							
5	Microthyriaceae indet.	X			1							
5	*Plochmopeltinites* sp. (Microthyriaceae)	X		2								
6	Varia	X	2	1	1	3	2	2			7	7
	SUM		87	133	147	306	674	59	102	11	637	569

PALYNOLOGICAL CHARACTERISTICS OF POLLEN SPECTRA FROM HORIZONS WITH PLANT MACROREMAINS

The state of preservation and frequency of sporomorphs considerably varied in particular samples, from 11 sporomorphs in two slides representing horizon 106–108 m from borehole core Komorniki 97/72 (KRAM-P 243/C) to over 500 sporomorphs in slides representing horizons 105–106 m from borehole core 97/72 (KRAM-P 243/B), 117 m from borehole core 97/72 (KRAM-P 243/E), and 110–111 m from borehole core Komorniki 97/73 (KRAM-P 244/D). The best preserved sporomorphs were found in horizons 117 m from borehole core 97/72 (KRAM-P 243/E), 102–105 m from borehole core 97/73 (KRAM-P 244/B), and 110–111 m from borehole core 97/73 (KRAM-P 244/D). Besides pollen grains and spores, freshwater plankton (algae, especially zygospores of Zygnemataceae) and sporocarps of Microthyriaceous fungi (probably from the genus *Plochmopeltinites*) were found. Results of palynological analyses of the samples, concerning botanical affinity and attachment to an appropriate palaeofloristic element, are shown in Table 3.

On the basis of pollen spectra the following plant communities are distinguished.

Azonal vegetation communities:

– Swamp forest (composed mainly of Taxodiaceae/Cupressaceae, including *Glyptostrobus* and *Taxodium,* also *Alnus*, and *Nyssa*)

– Riparian forest (*Salix*, *Alnus*, *Celtis*, *Ulmus, Carya*, and others)

– Bush swamp (Cyrillaceae, Clethraceae, Ericaceae, *Ilex*, and others)

– Rush vegetation (*Potamogeton*, *Sparganium* and Nymphaeaceae)

– Reeds and surrounding vegetation (Poaceae, *Rumex*, Asteraceae and Urticaceae)

Zonal vegetation community:

– Mesophytic Forest (composed mainly of deciduous trees *Quercus*, *Castanea*, *Betula*, *Fagus*, and coniferous trees *Picea*, *Abies*, *Tsuga* and others).

Geofloristic elements

The determined pollen taxa have been classified to the appropriate palaeofloristical elements mainly on the basis of the taxonomical revision of selected pollen and spores taxa from Neogene deposits (Ziembińska-Tworzydło et al. 1994) and other relevant publications (Ziembińska-Tworzydło 1996, 1998). The following elements were distinguished: palaeotropical (P): tropical (P1) and subtropical (P2), as well as arctotertiary (A): warm temperate (A1) and cool temperate (A2).

In the pollen spectra predominate representatives of arctotertiary warm temperate geofloristic element (A1, Tab. 3). The palaeotropical element is mainly represented by subtropical taxa (P2) such as *Araliaceoipollenites edmundi*, *A. euphorii*, *Arecipites* sp., *Castaneoideaepollis oviformis*, *C. pusillus*, *Cornaceaepollis major*, *Engelhardtioipollenites punctatus*, *Ilexpollenites iliacus*, *I. margaritatus*, *Myricipites* sp., *Platycaryapollenites miocaenicus*, *Quercoidites henrici*, *Tricolporopollenites exactus*, *T. fallax*, *T. liblarensis*, *T. pseudocingulum* s.l., and *T. quisqualis.*

Tropical taxa (P1) are represented by *Cornaceaepollis satzveyensis*, *Meliapollis* sp. and *Tricolporopollenites marcodurensis*. Broad-spectrum palaeotropical element (P) is represented by *Leiotriletes* sp. The presence (i.e. the proportion) of palaeotropical element is the most distinct in samples from the lowermost horizons with plant macroremains (horizons 117 m from borehole core 97/72 and 110–111 m from borehole core 97/73).

Composition of pollen spectra along with frequency of sporomorphs representing palaeotropical element point to the Middle Miocene (Badenian) age of samples and thereby to corresponding horizons with plant macroremains.

These preliminary palynological investigations of boreholes Komorniki 97/72 and 97/73 will be completed in the future by comprehensive investigation of the whole core samples.

PALAEOECOLOGICAL CHARACTERISTICS OF THE HORIZONS WITH PLANT MACROREMAINS

All horizons with plant macroremain assemblages are characterized by almost absolute dominance of floristic elements denoting wetland vegetation, which is confirmed by the results of palynological investigations. In the assemblages from horizons 78–79 m (KRAM-P 243/A), 105–106 m (KRAM-P 243/B), 106–108 m (KRAM-P 243/C), and 117 m (KRAM-P 243/E) from borehole Komorniki 97/72 and horizons 77–78 m (KRAM-P 244/A), 107–110 m (KRAM-P 244/C), and 110–111 m (KRAM-P 244/D) from borehole Komorniki 97/73 there were found almost exclusively taxa typical for wetland vegetation, especially those of swamp associations. In the assemblage from a 107–110 m depth of the borehole 97/73 there were found macroremains of water plants with submerged leaves belonging to the family Hydrocharitaceae, typical of water reservoirs with stagnant or slow-flowing water. Sediments from this horizon were most probably deposited in an oxbow lake. Only in horizons 112–115 m (KRAM-P 243/D) from the borehole 97/72 and 102–105 m (KRAM-P 244/B) from the borehole 97/73 there were found (apart from wetland taxa) macroremains of *„Castanea" kubinyii* and cf. *Carpinus grandis*, that are considered to be representatives of mesophytic vegetation. While *„Castanea" kubinyii* from the borehole 97/72 is relatively abundant with 16 specimens there, *Carpinus grandis* is represented only by a single specimen. Despite the fact that palynological spectra of the samples, taken from all horizons with plant macroremains reveal a continuous presence of mesophytic taxa, their frequency is indeed very low or even virtually never exceeding 5 grains per sample in case of some taxa. Total number of pollen grains of mesophytic taxa in the samples discussed did not exceed 10% of total number of all sporomorphs found (usually is about 5%).

On the basis of investigations on plant macroremains supplemented by the results of palynological analyses, reconstruction of the putative character of the local vegetation of the Ruja lignite deposit was assembled. We therefore assume, that the Ruja area was dominated by wetland vegetation with swamp and riparian forests. Swamp forests were composed of *Acer tricuspidatum*, *Alnus julianiformis*, *A. menzelii*, *Byttneriophyllum tiliifolium*, *Cercidiphyllum crenatum*, *Glyptostrobus europaeus*, *Myrica lignitum*, *Nyssa ornithobroma*, *Osmunda parschlugiana*, *Woodwardia muensteriana*, Zingiberaceae (*Spirematospermum* and *Zingiberoideophyllum*), representatives of the *Glyptostrobus-Alnus-Byttneriophyllum* association (Knobloch & Kvaček 1965, Givulescu 1992, Mai 1995). Forests of this type were present in Europe from the Upper Oligocene to the Pliocene, mainly in the Middle and Late Miocene in the area surrounding Paratethys (Mai op. cit). The presence of *Myrica lignitum* indicates that a local bog forest association could indeed have existed. The accumulation of wood, which later formed lignite seams, may have taken place in such a bog forest. The results of palynological investigations also point to the presence of bush swamp communities that were overgrown by representatives of the families Clethraceae, Cyrillaceae, and Ericaceae. Contemporary plant communities that correspond to the fossil associations recorded from Ruja occur in the south-eastern part of North America, mainly in the lowlands surrounding the Mississippi River, and on the south-eastern coast of the Atlantic. A typical cypress dominates in a swamp forest stand, occupying permanently inundated places, being composed of only few species, where *Taxodium distichum* (L.) Rich., *Nyssa aquatica* L. most often dominates, whilst *Planera* constitutes only the admixture. In localities with lower groundwater level, these forest associations are characterized by higher floristic diversity. In addition to *Taxodium*, *Nyssa* and *Planera* there are trees from the genera *Acer*, *Carya*, *Fraxinus*, *Liquidambar*, *Magnolia*, *Persea*, *Pinus*, *Quercus*, and *Ulmus*, accompanied by numerous shrubs (*Cephalantus*, *Cyrilla*, *Gordonia*, *Ilex*, *Swida*) and vines e.g. *Vitis* and *Smilax* (Knapp 1965, Kac 1975). As a contemporary equivalent to the Neogene bush swamp communities of Ruja the extant so-called "Pocosin" bush swamps from the south-eastern part of North America may be proposed. Pocosin is overgrown by acidophilous trees, shrubs, and shrublets with xeromorphic leaves represented by the genera *Andromeda*, *Chamaecyparis*, *Clethra*, *Cliftonia*, *Cyrilla*, *Ilex*, *Magnolia*, *Myrica*, *Pieris*, *Pinus*, *Rhamnus*, and *Vaccinium* (Knapp 1965).

Water reservoir margins were overgrown by reeds with *Phragmites oehningensis* and *Cyperacites* sp. (? *Sparganium*) dominating there, then being surrounded by waterside vegetation with Asteraceae, Poaceae, *Rumex*, and Urticaceae (traces of taxa characteristic of the latter ones were found in palynological samples). In the depths of water reservoirs stems and leaves of plants from the family Hydrocharitaceae were submerged. Palynological analysis revealed presence of *Potamogeton* and Nymphaeaceae, plants with floating leaves, as well as of algae from the family Zygnemataceae (probably belonging to the genera *Spirogyra* and *Zygnema*).

Slightly drier areas, formed probably on mineral soils, that were inundated only periodically, were covered with riparian forests, which is indicated by the presence of such taxa as *Populus populina*, *Pterocarya paradisiaca*, *Salix* spp., *Ulmus* cf. *ruszovensis*, *U. pseudopyramidalis*, and *Zelkova zelkovifolia*. In Europe this type of forest occurred from the Middle Palaeocene to the earliest Pleistocene (Mai 1995). Similar riparian associations today exist in the south-eastern part of North America, most often occupying river valleys, river banks within the range of episodic flooding (Knapp 1965, Barnes 1991) as well as in the Euxine-Hyrcanian area (Anatolia, Colchis, Talysh, Iranian coast of the Caspian Sea, Tutayuk 1975, Rastin 1983, Akhani & Salimian 2003). The abundance of leaf remains belonging to various species of the genus *Salix* (*S. hausruckensis*, *S.* cf. *kicktonii*, *S. varians*, and *Salix* ssp.), especially in horizon 102–105 m from borehole Komorniki 97/73 points to the presence of riparian willow communities.

Higher elevated terrain with low groundwater level, placed above the maximum level of periodical flood inundation, was marked with the presence of mesophytic forests. Due to very poor representation of this group of plants in macroremain assemblages of Ruja, with only leaves of *„Castanea" kubinyii* and cf. *Carpinus grandis* being found, composition of the zonal mesophytic vegetation of Ruja was reconstructed mostly on the basis of the results of palynological investigations. Mixed mesophytic forests there were among the others composed of angiosperms such as *Betula*, *Castanea*, *Fagus*, *Quercus* and conifers like *Abies*, *Keteleeria*, *Tsuga*. In the oldest horizons with plant macroremains these associations correspond to the Mixed Mesophytic Forest sensu Mai (1995), which is indicated by a considerable share of palaeotropical taxa in pollen spectra. In the present times similar mixed mesophytic forests occur in central China, mainly in the Yangtze River watershed (Wang 1961). In these forests there occur trees, shrubs and lianas representing the following genera: *Acer*, *Alnus*, *Betula*, *Carpinus*, *Carya*, *Celtis*, *Cercidiphyllum*, *Fagus*, *Fraxinus*, *Kalopanax*, *Liquidambar*, *Magnolia*, *Nyssa*, *Ostrya*, *Phellodendron*, *Populus*, *Pterocarya*, *Quercus*, *Tilia*, and *Ulmus*, evergreen trees and shrubs of the genera *Castanopsis*, *Michelia*, and *Pasania*, and representatives of the family *Lauraceae*. Mesophytic forests from younger horizons with plant macroremains correspond to deciduous broad-leaved forests (Kovar-Eder 2003) of the association *Quercus-Carpinus-Castanea* association sensu Mai (1995). As their contemporary equivalent there could be considered floristically rich mesophytic deciduous forests from the eastern part of North America (Braun 1964, Knapp 1965, Barnes 1991).

RECONSTRUCTION OF PALAEOCLIMATE

Almost all taxa of plant macroremains found in the investigated sediment parts of the "Ruja" lignite deposit represent the arctotertiary geofloristic element (Engler 1882, Mai 1995). Their contemporary counterparts are characteristic of modern warm temperate ecosystems in the northern hemisphere. Dominance of this particular group of plants implies warm temperate climate prevailing during the period of formation of these macroremain assemblages. Plant macroremains of palaeotropical element of the family Zingiberaceae (genera *Spirematospermum* and *Zingiberoideophyllum*) and *Glyptostrobus europaeus*, as well as the presence of taxa represented mainly by subtropical taxa (P2) in the pollen spectra suggest mild winters with the absolute minima staying above –5°C. Furthermore, the absence of more thermophilous plants such as Lauraceae or palms, combined with rarity of palaeotropical taxa among plant macroremains rule out subtropical climate.

The palaeoclimate may have been comparable to contemporary climate of the Talysh and Colchis in Transcaucasia, where the Euxine-Hyrcanian forests did exist. In this region are growing *Alnus subcordata* C. A. Mey, similar to the fossil species *Alnus menzelii* Raniecka-Bobrowska, *Pterocarya pterocarpa* (Michaux) Knuth, comparable to the fossil species *Pterocarya paradisiaca* (Unger) Ilinskaya, and *Zelkova carpinifolia* (Pall.) Dipp. related to *Zelkova zelkovifolia* (Tutayuk 1975). The climate of this area is mild with mean annual temperatures oscillating around +14°C and the mean temperature of the coolest month being +3°C (Tutayuk op cit.). Frosts rarely occur, and annual precipitation is high (1250 mm). In the same manner, the Neogene of Ruja may have been similar to the climatic conditions of the southeastern part of North America (the Mississippi River delta and the southeastern coast of the Atlantic) where *Acer rubrum* var. *drummondii* (Hook & Arnott) Sarg. occurs, relative of the fossil species *A. tricuspidatum*. The mean annual temperature of this area varies between +16 and +19.8°C; the temperature of the mean coolest month spans +5 and +15°C, and high annual precipitation reaches up to 1200–1500 mm (Knapp 1965, Barnes 1991).

AGE OF THE HORIZONS WITH PLANT REMAINS

Most of the horizons with plant macroremains from the borehole Komorniki 97/72 (KRAM-P: 243/B, 243/C, 243/D) and of the borehole Komorniki 97/73 (KRAM-P: 244/B, 244/C, 244/D) come from the Pawłowice Formation (the Middle Miocene) and two horizons from both boreholes (KRAM-P: 243/A and 244/A) lie in the lowermost part of the Poznań Formation in the horizon equivalent to 1st Mid-Polish seam (the Middle Miocene). Considering this, from the geological point of view, the age of all horizons with plant remains should be estimated as the Middle Miocene. This conclusion is in accordance with results of our palaeobotanical investigations. Floristic composition of all levels with plant macroremains is similar in respect of the taxonomical composition (Tab. 1, 2) and points to their Neogene age. Absence of fossil leaves of *Quercus rhenana* (Kräusel & Weyland) Knobloch & Z. Kvaček, very characteristic of the Central European Early Miocene swamp vegetation and common among macroremains of swamp associations of this period, and absence of the members of the family Lauraceae and palms (Arecaceae), make the Early Miocene age of this part of the Neogene sediments of the "Ruja" lignite deposit rather unlikely. Domination of the deciduous, warm temperate climate species, presence of taxa absent or very rare in the Pliocene floras of Poland (*Byttneriophyllum tiliifolium*, *Glyptostrobus europaeus*, *Zingiberoideophyllum liblarense*), and absence of taxa characteristic of Central European Pliocene fossil floras, closely related to or identical with recent species (e.g. *Quercus castaneifolia* C.A. Mey. foss. and *Ulmus carpinifolia* Gled. foss. in Willershausen, Wilde et al. 1992) allow to exclude the Pliocene age and suggest the Middle or Late Miocene age. Results of palynological investigations specify this evaluation, and point to the Middle Miocene (Badenian) age of horizons with plant macroremains.

COMPARISON OF PLANT MACROREMAIN ASSEMBLAGES WITH OTHER NEOGENE LEAF FLORAS FROM POLAND AND CENTRAL EUROPE

Assemblages of plant macroremains from both boreholes from Ruja lignite deposit are taxonomically similar to leaf floras found in deposits that were formed in fluvial and swamp environments generating lignite deposits during the Neogene in Poland and Central Europe. From the Neogene of Poland most similar macroremain assemblages to that of Ruja are leaf floras from Middle Miocene of Dobrzyń on Vistula River (Kownas 1956, 1959), and especially Late Miocene leaf assemblages from the Bełchatów Lignite Mine (Stuchlik et al. 1990, Worobiec & Lesiak 1998, Worobiec 2003, Worobiec & Szynkiewicz 2007). Leaf flora from Dobrzyń on the river Vistula has 11 taxa common with Ruja and Bełchatów Lignite Mine – 13 taxa (Tab. 4). Similarly as in Ruja in all the above mentioned fossil floras macroremains of swamp forests *sensu* Mai (1995) dominated, mainly *Glyptostrobus-Alnus-Byttneriophyllum* swamp association (Knobloch & Kvaček 1965, Givulescu 1992) with characteristic taxa such as *Alnus menzelii*, *Byttneriophyllum tiliifolium*, *Glyptostrobus europaeus*, and *Myrica*. Also in the Miocene flora from Nysa (Krajewska 2001) and the Middle Miocene flora of Konin (Raniecka-Bobrowska 1954) there were found remains of *Byttneriophyllum tiliifolium* leaves (Tab. 4). However, this last two floras have only up to 3 taxa in common. The Middle Miocene leaf flora from Stawiany and Młyny in the southern margin of Holy Cross Mountains (Zastawniak 1980) is ecologically completely different (Tab. 4) and share with Ruja only taxa typical for riparian communities (e.g. *Alnus julianiformis*, *Pterocarya paradisiaca*, *Zelkova zelkovifolia*).

Outside of Poland, macroremain assemblages with dominance of *Glyptostrobus-Alnus-Byttneriophyllum* association are known from numerous localities from Austria, Bulgaria, Czech Republic, Germany, Hungary, Romania,

Table. 4. The occurrence of fossil taxa of the Ruja lignite deposit in the selected leaf floras of the Neogene of Poland. (+) - taxon given under another name

Taxon	MIDDLE MIOCENE			LATE MIOCENE	MIOCENE
	DOBRZYŃ ON VISTULA RIVER (Kownas 1956, 1959)	KONIN (Raniecka-Bobrowska 1954)	STAWIANY, MŁYNY (Zastawniak 1980)	BEŁCHATÓW (Stuchlik et al. 1990, Worobiec & Lesiak 1998, Worobiec 2003, Worobiec & Szynkiewicz 2007)	NYSA (Krajewska 2001)
Osmunda parschlugiana					
Woodwardia muensteriana	+				
Glyptostrobus europaeus	+	+		+	
Sequoia abietina	(+)			+	
Acer tricuspidatum	(+)		+		+
Alnus julianiformis			+	+	
Alnus menzelii	+	+		+	
Byttneriophyllum tiliifolium	(+)			+	+
„Ficus" truncata				+	
Cercidiphyllum (?) *crenatum*					
Myrica lignitum	?			+	
Populus populina					
Salix hausruckensis					
Salix cf. *kicktonii*					
Salix varians	+			+	
Pterocarya paradisiaca			+	+	
"Castanea" kubinyii				+	
Nyssa ornithobroma				+	
Ulmus pseudopyramidalis					
Ulmus cf. *ruszovensis*					
Zelkova zelkovifolia			+		
Phragmites oeningensis	+		+		
Zingiberoideophyllum liblarense	(+)			+	
Spirematospennum wetzleri	+			+	
Hydrocharitaceae leaves		+			
Cyperacites					

Slovakia, and Ukraine (Mai 1995). Rather similar leaf assemblages (Tab. 5) were found in Lower Miocene deposits of Wackersdorf (Knobloch & Kvaček 1976, 10 common taxa), Middle Miocene of Precarpathians (Shvareva 1983, 9 common taxa) and the Late Miocene of Molassezone of Austria (Kovar-Eder 1988, 9 common taxa). The Middle Miocene leaf floras from Kreuzau (Ferguson 1971) and Hinterschlagen (Kovar-Eder & Wójcicki 2001) has only 6 (Kreuzau) or 5 (Hinterschlagen) taxa in common (Tab. 5), but only in flora of Hinterschlagen, besides Ruja, leaves of *Salix hausruckensis* were found. The Late Miocene flora from Mataschen (Kovar-Eder 2004) has only 3 taxa common with Ruja deposits but there was found *Zingiberoideophyllum liblarense*, fossil representative of the family Zingiberaceae, typical for *Glyptostrobus-Alnus-Byttneriophyllum* association.

CONCLUSIONS

As the result of investigation of 280 specimens of plant macroremains from the two cores of Ruja locality (Komorniki 97/72 and Komorniki 97/73), 35 taxa from 24 genera belonging to 16 families of pteridophyta, gymnosperms and angiosperms were identified.

Five new species were reported for the Polish Neogene: *Salix hausruckensis*, *Salix* cf. *kicktonii* Weyland, *Salix* sp. 1, *Ulmus pseudopyramidalis* Z. Kvaček & Hably, and cf. *Varipilicutis liblarensis* (Kräusel & Weyland) Schneider.

Pollen spectra from samples taken from all horizons with plant macroremains contain a predominance of taxa representing azonal vegetation communities (mostly swamp and riparian forests and bush swamps). Sporomorphs representing zonal mespohytic forest

Table. 5. The occurrence of fossil taxa of Ruja lignite deposit in the selected leaf floras of the Neogene of Central Europe. (+) - taxon given under another name

Taxon	EARLY MIOCENE	MIDDLE MIOCENE		LATE MIOCENE		
	WACKERSDORF (Knobloch & Kvaček 1976)	KREUZAU (Ferguson 1971)	PRECARPATHIANS (Shvareva 1983)	HINTERSCHLAGEN (Kovar-Eder & Wójcicki 2001)	MOLASSEZONE OF AUSTRA (Kovar-Eder 1988)	MATASCHEN (Kovar-Eder 2004)
Osmunda parschlugiana						
Woodwardia muensteriana						
Glyptostrobus europaeus	+		+		+	+
Sequoia abietina					+	
Acer tricuspidatum	+		(+)		+	
Alnus julianiformis	+			+		
Alnus menzelii				+		
Byttneriophyllum tiliifolium			(+)		+	
„Ficus" truncata		(+)				
Cercidiphyllum (?) *crenatum*		+	+			
Myrica lignitum	+	+	+		+	
Populus populina	+	+	+		+	
Salix hausruckensis				+		
Salix cf. *kicktonii*						
Salix varians	+	+				+
Pterocarya paradisiaca	+		+		+	
"Castanea" kubinyii	+	+		+	?	
Nyssa ornithobroma						
Ulmus pseudopyramidalis						
Ulmus cf. *ruszovensis*						
Zelkova zelkovifolia	+	+	+	+	+	
Phragmites oeningensis			+			
Zingiberoideophyllum liblarense	+					+
Spirematospennum wetzleri						
Hydrocharitaceae						
Cyperacites						

vegetation are rare. Taxa belonging to arctotertiary, warm temperate element (A1) prevail in the pollen spectra. The presence of a palaeotropical element, mainly represented by subtropical taxa (P2) is the most distinct in samples from the lowermost horizons with plant macroremains.

The Ruja area in the Middle Miocene was dominated by wetland vegetation with swamp and riparian forests. Swamp forest was composed of *Acer tricuspidatum*, *Alnus menzelii*, *Byttneriophyllum tiliifolium*, *Cercidiphyllum crenatum*, *Glyptostrobus europaeus*, *Myrica lignitum*, *Nyssa ornithobroma*, *Osmunda parschlugiana*, *Woodwardia muensteriana*, and Zingiberaceae (*Spirematospermum* and *Zingiberoideophyllum*), representatives of the association *Glyptostrobus-Alnus-Byttneriophyllum*. Results of palynological investigations also point to the presence of the bush swamp communities. Slightly drier areas probably on mineral soils only periodically flooded were dominated by the riparian forests as indicated by the presence of such taxa as *Populus populina*, *Pterocarya paradisiaca*, *Salix* spp., *Ulmus* cf. *ruszovensis*, *U. pseudopyramidalis*, and *Zelkova zelkovifolia*. Reservoir margins were covered with reeds, i.e. *Phragmites oehningensis* and *Cyperacites* sp. (? *Sparganium*) and surrounded by waterside vegetation with Asteraceae, Poaceae, *Rumex*, and Urticaceae. In the depths of reservoirs there were submerged stems and leaves belonging to the members of the family Hydrocharitaceae; on the open surface there were floating leaves of *Potamogeton* and Nymphaeaceae. Mesophytic forests occupied higher elevated terrain.

Almost all fossil plant macroremain taxa found in the investigated sediments of the Ruja lignite deposit represent warm temperate arctotertiary element and indicate warm temperate climate during the period when the deposition of macroremain assemblages occurred. The presence of plant macroremains denoting palaeotropical element (Zingiberaceae) as well as taxa reflecting subtropical palaeotropical element (P2) in pollen spectra, points to mild winters with absolute minimum temperatures not falling below –5°C. Palaeoclimate at the time of sedimentation of horizons with plant macroremains of Ruja could be similar to the contemporary climate of the Talysh and Colchis in Transcaucasia or south-eastern part of USA.

Geological position and floristic composition of all investigated levels with plant macroremains point to the Middle Miocene (Badenian) age.

Plant macroremains from both boreholes of the Ruja lignite deposit suggest that in the Middle Miocene there existed the area of swamp forests sensu Mai (1995), in type of the *Glyptostrobus-Alnus-Byttneriophyllum* swamp association (Knobloch & Kvaček 1965, Givulescu 1992) thriving upon fluvial and swamp habitats, generating in effect lignite deposits during the Neogene period in Central Europe.

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REFERENCES

AKHANI H. & SALIMIAN M. 2003. An extant disjunct stand of *Pterocarya fraxinifolia* (Juglandaceae) in the central Zagros Mountains, W Iran. Willdenowia, 33: 113–120.

ANCIBOR E. 1979. Systematic anatomy of vegetative organs of the Hydrocharitaceae. Bot. J. Linn. Soc., 78: 237–266.

ANDREÁNSZKY G. 1959. Die Flora der sarmatischen Stufe in Ungarn. Akadémiai Kiadó, Budapest.

APG II. 2003. An update of the Angiosperm Phylogeny Group classification for orders and families of flowering plants: APG II. Bot. J. Linn. Soc., 141: 399-436.

BARANOWSKA-ZARZYCKA Z. 1988. Main features of the Pliocene fruit-seed flora from Ruszów near Żary (West Poland). Acta Palaeobot., 28: 23–27.

BARNES B.V. 1991. Deciduous forests of North America: 219–344. In: Röhrig E. & Ulrich B. (eds) Ecosystems of the World 7: Temperate deciduous forests. Elsevier Science Pub., Amsterdam, London, New York, Tokyo.

BELZ G. & MOSBRUGGER V. 1994. Systematisch-paläoökologische und paläoklimatische Analyse von Blattfloren im Mio-/Pliozän der Niederrheinischen Bucht (NW-Deutschland). Palaeontographica, B, 233(1-6): 19-156.

BIRKENMAJER K. 1967. Bazalty dolnośląskie jako zabytki przyrody nieożywionej. Ochr. Przyrody, 32: 225–276.

BORATYŃSKI A. & BORATYŃSKA K. 1975. Geograficzne rozmieszczenie *Pterocarya fraxinifolia* Spach (summary: Geographical distribution of *Pterocarya fraxinifolia* Spach). Arbor. Kórnickie, 20: 131–138.

BRAUN A. 1836. In: W. Buckland: Geology and mineralogy considered with reference to natural theology, 1: 510–514. W. Pickering, London.

BRAUN A. 1845. Die Tertiär-Flora von Öningen. Neu. Jahrb. Mineral. Geol. Petrefaktenk., 1: 146–173.

BRAUN E.L. 1964. Deciduous forests of Eastem North America. Hafner Publishing Company, New York, London.

BRAUN F. 1841. Beiträge zur Kenntnis fossiler Gewächse. Flora 24, 1: 33–38.

BRONGNIART A. 1822. Sur la classification et la distribution des végétaux fossil en général, et sur ceux des terrains de sédiment supérieur en particulier. Mém. Mus. Hist. Natur., 8: 203–240.

BRONGNIART A. 1833. Notice sur une Conifère fossile du terrain d'eau douce de l'Ile d'Iliodroma. Ann. Sci. Nat. Sér., 30: 168–176.

BRONN H.G. 1838. Lethaea geognostica 2. Schweizerbartscher Verlag, Stuttgart.

BROWN R.W. 1935. Miocele leaves, fruits, and seeds of *Cercidiphyllum*. J. Paleont., 9: 572–587.

BRUD S. & WOROBIEC G. 2003. Wyniki badań makroszczątków roślin z serii witowskiej (południowa Polska) (summary: Results of investigations on plant macroremains found in depoosits of the Witów Series (southern Poland)). Prz. Geol., 51(5): 392–401.

BŮŽEK Č. 1971. Tertiary flora from the northern parth of the Pětipsy Area (North-Bohemian Basin). Rozpr. Ústř. Úst. Geol., 36: 1–118.

BŮŽEK Č., HOLÝ F. & KVAČEK Z. 1996. Early Miocene flora of the Cypris Shale (Western Bohemia). Acta Mus. Nation. Prague, ser. B, Hist. Nat., 52: 1–72.

CHANDLER M.E.J. 1925. The Upper Eocene flora of Hordle, Hants. I. Paleontogr. Soc., 77(1923): 1–32.

CUVIER G. 1822. Recherches sur les ossemens fossiles: ou l'on rétablit les caractères de plusiers animaux dont les révolutions du globe ont détruit les espèces. G. Dufour and E. d'Ocagne, Paris.

CZECZOTT H. 1934. Co to jest *Fagus feroniae* Ung. (summary: What is *Fagus feroniae* Ung.). Acta Soc. Bot. Pol., Suppl., 11: 109-116.

CZECZOTTOWA H. 1951. Środkowo-mioceńska flora Zalesiec koło Wiśniowca 1. Acta Geol. Pol., 2: 349–445.

CZECZOTT H. 1967. Dicotyledones: Sterculiaceae. In: Czeczott H. (ed.) Flora kopalna Turowa koło Bogatyni (summary: The fossil flora of Turów near Bogatynia 2). Systematyczny opis szczątków roślinnych 3 (Systematic description of plant remains 3). Pr. Muz. Ziemi, 10: 115–122, 152–156.

CZECZOTT H. & SKIRGIEŁŁO A. 1961. Dicotyledones: Juglandaceae. In: Czeczott H. (ed.) Flora kopalna Turowa koło Bogatyni 2 (summary: The fossil flora of Turów near Bogatynia 2). Systematyczny opis szczątków roślinnych 2 (Systematic description of plant remains 2). Pr. Muz. Ziemi, 4: 51–73.

DILCHER D.L. 1974. Approaches to the identification of Angiosperm leaf remains. Bot. Rev., 40(1): 1–157.

DYJOR S., KVAČEK Z., ŁAŃCUCKA-ŚRODONIOWA M., PYSZYŃSKI W., SADOWSKA A. & ZASTAWNIAK E. 1992. The Younger Tertiary deposits in the Gozdnica region (SW Poland) in the light of recent palaeobotanical research. Pol. Bot. Stud., 3: 3–129.

DYLĄG J.K. 1995. Złoże węgla brunatnego „Ruja" w Legnickim Kompleksie Złóż Węglowych: 11–13. In: Lipiarski I. (ed.) Materiały XVIII Sympozjum „Geologia Formacji Węglonośnych Polski", AGH, Kraków, 5–6 kwietnia 1995. Wyd. AGH, Kraków.

ENGELHARDT H. 1877. Tertiärpflanzen von Kunzendorf bei Sagan in Schlesien. Sitz.-Ber. Naturwiss. Ges. Dresden, 1: 1–3.

ENGELHARDT H. 1887. Ueber Tertiärpflanzen von Grünberg in Schlesien aus dem Provincial Museum zu Königsberg in Pr. Schr. Phys.-Ökon. Ges., 27 (1886).

ENGELHARDT H. 1892. Ueber neue Tertiärpflanzen von Grünberg in Schlesien. Abh. Naturwiss. Ges. Dresden, 5: 1–4.

ENGLER A. 1882. Versuch einer Entwicklungsgeschichte der Plfanzenwelt seit der Tertiärperiode 2. W. Engelmann, Leipzig.

ETTINGSHAUSEN C. 1852. Fossile Pflanzenreste aus dem trachytischen Sandstein von Heiligenkreuz bei Kremnitz. Abh. Kaiserl. König. Geol. Reichsanst., 3(5): 1–14.

FAEGRI K. & IVERSEN J. 1975. Textbook of Pollen Analysis. Munksgaard, Copenhagen.

FERGUSON D.K. 1971. The Miocene flora of Kreuzau, Western Germany, 1. The leaf-remains. Verh. Kon. Nederl. Akad. Wetensch., Afc. Naturk., Tweede Reeks, 60: 1–297.

FRIEDRICH W.L. & KOCH B.E. 1970. Comparison of fruits and seeds of fossil *Spirematospermum* (Zingiberaceae) with those of living *Cenolophon*. Bull. Geol. Soc. Denmark, 20(2): 192–195.

FRIIS E.M. 1988. *Spirematospermum chandlerae* sp. nov., an extinct species of Zingiberaceae from the North American Cretaceous. Tertiary Res., 9: 7–12.

GASTALDO R.A., FERGUSON D.K., WALTHER H. & RABOLD J.M. 1996. Criteria to distniguish parautochthonous leaves in Tertiary alluvial channel-fills. Rev. Palaeobot. Palynol., 91(1–4): 1–21.

van GEEL B., COOPE G.R. & van der HAMMEN T. 1989. Palaeoecology and stratigraphy of the lateglacial type section at Usselo (The Netherlands). Rev. Palaeobot. Palynol., 60: 25–129.

GIVULESCU R. 1979: Paläobotanische Untersuchungen im Pfanzenfundort Chiuzbaia (Kreis Maramures - Rumänien). Mém. Inst. Géol. Géophys. Bucuresti, 28: 65–146.

GIVULESCU R. 1992. Les forêts marécageuses du Miocéne supérieur de Roumanie: un paléobiotope d'exception et sa végétation dans le Miocène supérieur de I'ouest de la Roumanie: 147–152. In: Kovar-Eder J. (ed.) Palaeovegetational development in Europe and Regions Relevant to its Palaeofloristic Evolution. Naturhist. Mus., Wien.

GOEPPERT H.R. 1852. Beiträge zur Tertiärflora Schlesiens. Palaeontographica, 2(6): 257–282.

GOEPPERT H.R. 1855. Die tertiäre Flora von Schossnitz in Schlesien. Heynsche Buchh., Görlitz.

GREGOR H-J. 1989. Neue geologisch-paläontologische Ergebnisse aus den Tagebauen der "Oberpflezer Braunkohle" (Naab-Molasse, Miozn). Documenta Naturae, 55: 1–78.

HABLY L. & KOVAR-EDER J. 1996. A representative leaf assemblage of the Pannonian Lake from Dozmat near Szombathely (Western Hungary), Upper Pannonian, Upper Miocene: 69–80. In: Dudich E. & Lobitzer H. (eds) Advances in Austrian - Hungarian Joint Geological Research. Geol. Bundesanstalt., Wien.

HABLY L. & KVAČEK Z. 1997. Early Pliocene plant megafossils from the volcanic area in West Hungary. Studia Naturalia, 10: 5–151.

HABLY L. & ZASTAWNIAK E. 2001. Distribution, taphonomy and palaeoecology of *Ulmus* L. in the Hungarian Egerian. Studia Bot. Hung., 32: 13–32.

HANTKE R. 1954. Die fossile Flora der obermiozänen Oehninger-Fundstelle Schrotzburg (Schienerberg, Süd-Baden). Denkschr. Schweiz. Naturf. Ges., 80(2): 31–118.

HEER O. 1855. Die tertiäre Flora der Schweiz (Flora tertiaria Helvetiae), vol. 1. J. Wurster-Comp., Winterthur.

HEER O. 1856. Die tertiäre Flora der Schweiz (Flora tertiaria Helvetiae), vol. 2. J. Wurster-Comp., Winterthur.

HEER O. 1859. Die tertiäre Flora der Schweiz (Flora tertiaria Helvetiae), vol. 3. J. Wurster-Comp., Winterthur.

HEER O. 1869. Miocene baltische Flora. Beitr. Naturk. Preußens, 2: 1–104.

HENRY A. & McINTYRE M. 1926. The Swamp Cypresses, *Glyptostrobus* of China and *Taxodium* of America, with notes on allied genera. Proc. Royal Irish Acad., 37, B 13: 90–113.

HICKEY L.J. 1979. A revised classification of the architecture of dicotyledonous leaves: 25–39. In: Metcalfe C.R. & Chalk L. (eds) Anatomy of the Dicotyledons. Second Edition, vol. 1. Clarendon Press, Oxford.

HICKEY L.J. & PETERSON R.K. 1978. *Zingiberopsis*, a fossil genus of the ginger family from Late Cretaceous to early Eocene sediments of Western Interior North America. Can. J. Bot., 56: 1136–1152.

HIÊP N.T. & VIDAL J.E. 1996. Gymnospermae. In: Morat P. (ed.) Flore du Cambodge du Laos et du Viêtnam. Mus. National d'Hist. Naturelle, Paris, 28.

HUMMEL A. 1970. *Cercidiphyllum* we florze Turowa. Kwart. Geol., 14(4): 803–809.

HUMMEL A. 1975. Dicotyledoneae; Ulmaceae, Cercidiphyllaceae. In: Czeczott H. (ed.) Flora kopalna Turowa koło Bogatyni (summary: Ulmaceae, Cercidiphyllaceae. The fossil flora of Turów near Bogatynia). Pr. Muz. Ziemi, 24: 11–23.

HUMMEL A. 1983. The Pliocene leaf flora from Ruszów near Żary in Lower Silesia, SW Poland. Pr. Muz. Ziemi, 36: 9–104.

HUMMEL A. 1991. The Pliocene leaf flora from Ruszów near Żary in Lower Silesia, South-West Poland. Part 2. (Betulaceae). Acta Palaeobot., 31(1–2): 73–151.

ILINSKAYA I.A. 1962. Tortonskaya flora Svoshovitse i pliotsenovye flory Zakarpat'ya. Paleontol. Zhurn., 3: 102–110.

ILINSKAYA I.A. 1964. Tortonskaya flora Svoshovitse (summary: The Tortonian flora of Swoszowice). Tr. Bot. Inst. AN SSSR, Ser. 8, Paleobot., 5: 115–144.

ILINSKAYA I.A. 1968. Neogenovye flory Zakarpatskoi oblasti USSR (summary: Neogene floras of the Transcarpathian Region of the U.S.S.R.). Izdatel'stvo Nauka, Leningrad.

JAROŃ L., KONDRATOWICZ A. & ŻYGA J. 1978. Budowa geologiczna złóż węgli brunatnych Legnica i Ścinawa oraz perspektywy ich eksploatacji. Prz. Geol., 26: 10.

JĘCZMYK M., KASIŃSKI J. R., PIWOCKI M. & SZTROMWASSER E. 1997. Minerały ciężkie i złoto w seriach płonnych złoża węgla brunatnego Ruja. Prz. Geol., 45(1): 97–100.

JUCHNIEWICZ K. 1966. O metodach badania anatomicznego liści w paleobotanice. Wiad. Bot., 19(2): 115-121.

JUHNKE R. 1931. Neue tertiäre Pflanzenfunde im Kreise Wohlau. Jahrb. Preuß. Geol. Landesanst., 52: 112–118.

KAC N.J. 1975. Bagna Kuli Ziemskiej. PWN, Warszawa.

KASIŃSKI J.R. & PIWOCKI M. 2005. Baza surowcowa węgla brunatnego zabezpieczająca budowę Kopalni Legnica. In: Trembecki S. & Łoński A. (eds) Konferencja Naukowa „Rekonstrukcja polskiej gospodarki jako szansa opanowania bezrobocia realizowana budową Legnickiego Zagłębia Węgla Brunatnego". Wyższa Szkoła Menedżerska, Legnica: 22–39.

KASIŃSKI J.R., DYLĄG J.K. & SATERNUS A. 1995 Tertiary lignite-bearing association of the Ruja tectonic depression, Legnica-Ścinawa lignite-bearing complex, SW Poland. In: Pešek J., Opluštil S., Peškova J. & Skoček V. (eds) European Coal Conference "Coal prospecting, exploration and evaluation, utilization, coalbed methane and environmental impacts". Univ. Kràlova, Praha: 83 abstract.

KEARNEY T.H. 1901. Report on a botanical survey of the dismal swamp region. Contributions from the U.S. National Herbarium, 5(6): 321–585.

KNAPP R. 1965. Die Vegetation von Nord- und Mittelamerika und der Hawaii-Inseln. Gustav Fischer Verlag, Stuttgart.

KNOBLOCH E. 1964. Haben *Cinnamomum scheuchzeri* Heer und *Cinnamomum polymorphum* (A. Braun) Heer nomenklatorisch richtige Namen? Neues. Jahrb. Geol. Paläont., Monatshefte, 10: 597–603.

KNOBLOCH E. 1969. Tertiäre Floren von Mähren. Moravské Museum-Musejní Spolek. Brno.

KNOBLOCH E. 1971. Nomenklatorische-taxonomische Bemerkungen zu *Platanus aceroides* Goeppert und *Quercus attenuata* Goeppert. Mitt. Bayer. Staatssaml. Paläont. Hist. Geol., 11: 263–265.

KNOBLOCH E. & KVAČEK Z. 1965. *Byttneriophyllum tiliaefolium* (Al. Braun) Knobloch et Kvaček in den tertiären Floren der Nordhalbkugel. Sbor. Geol. Věd., Paleont., 5: 123–166.

KNOBLOCH E. & KVAČEK Z. 1976. Miozäne Blätterfloren vom Westrand der Böhmischen Masse. Rozpr. Ústř. Úst. Geol., 42: 1–131.

KNOBLOCH E. & KVAČEK Z. 1996. Miozäne Floren der südböhmischen Becken. Sbor. Geol. Věd, Paleont., 33: 39–77.

KOTLABA F. 1963. Tertiary plants from three new localities in Southern Slovakia. Acta Mus. Nat. Ser. Hist. Nat. B, 19(2): 53–72.

KOVAR-EDER J. 1988. Obermiozäne (Pannone) Floren aus der Molassezone Österreichs. Beitr. Paläont. Österr., 14: 19–121.

KOVAR-EDER J. 1996. Eine bemerkenswerte Blätter-Vergesellschaftung aus dem Tagebau Oberdorf bei Köflach, Steiermark (Unter-Miozän). Mitt. Abt. Geol. Paläont. Landesmus. Joanneum, 54: 147–171.

KOVAR-EDER J. 2003. Vegetation dynamics in Europe during the Neogene. In: Reumer J.W.F. & Wessels W. (eds) Distribution and migration of Tertiary mammals in Eurasia. A volume in honour of Hans de Bruijn. Deinsea, 10: 373–392.

KOVAR-EDER J. 2004. Die obermiozäne Flora von Mataschen bei Fehring, Steiermark - Blattvergesellschaftungen. Joannea – Geol. Paläont., 5: 163–176.

KOVAR-EDER J. & KRAINER B. 1991. Flora und Sedimentologie der FundsteIle Reith bei Unterstorcha, Bezirk Feldbach in der Steiermark (Kirchberger Schotter, Pannonium C, Miozän). Jahrb. Geol. Bundesanst., 134(4): 737–771.

KOVAR-EDER J. & MELLER B. 2003. The plant assemblages from the main seam parting of the western sub-basin of Oberdorf, N Voitsberg, Styria, Austria (Early Miocene). Cour. Forsch.-Inst. Senckenberg, 241: 281–312.

KOVAR-EDER J. & WÓJCICKI J.J. 2001. A Late Miocene (Pannonian) flora from Hinterschlagen, Hausruck lignite area, Upper Austria. Acta Palaeobot., 41(2): 221–251.

KOVAR-EDER J., KVAČEK Z. & MELLER B. 2001. Comparing Early to Middle Miocene floras and probable vegetation types of Oberdorf N Voitsberg (Austria), Bohemia (Czech Republic) and Wackersdorf (Germany). Rev. Palaeobot. Palynol., 114: 83–125.

KOVAR-EDER J., MELLER B. & ZETTER R. 1998. *Cercidiphyllum crenatum* (Unger) R.W.Brown in der kohleführenden Abfolge von Oberdorf N Voitsberg, Steiermark. Mitt. Ref. Geol. Paläont. Landesmus. Joanneum, SH2: 239–264.

KOVATS J. 1851. Fossile Flora von Erdöbénye. Jahrb. Kaiserl. Königl. Geol. Reichsanst., 2(2): 178.

KOWNAS S. 1956. Trzeciorzędowa flora z Dobrzynia nad Wisłą (summary: Tertiary flora from Dobrzyń on the Vistula). Acta Geol. Pol., 5(4): 439–516.

KOWNAS S. 1959. Przedstawiciele rodziny Zingiberaceae w trzeciorzędzie Dobrzynia nad Wisłą (summary: Representatives of the Zingiberaceae in the Miocene beds at Dobrzyń on the Vistula, Poland). Acta Soc. Bot. Pol., 28: 461–470.

KRAJEWSKA K. 1998. Neogene leaf flora from Gnojna (Opole Prov., SW Poland). Acta Palaeobot., 38(1): 25–85.

KRAJEWSKA K. 2001. Miocene leaf flora from Nysa (SW Poland). Pr. Muz. Ziemi, 46: 129–144.

KRÄUSEL R. 1919. Die Pflanzen des schlesischen Tertiärs. Jahrb. Preuß. Geol. Landesanst., 38(1917), 1(2): 1–338.

KRÄUSEL R. 1920. Nachträge zur Tertiärflora Schlesiens. 1. Jahrb. Preuß. Geol. Landesanst., 39(1918), 1(3): 329–417.

KRÄUSEL R. 1921. Nachträge zur Tertiärflora Schlesiens. 3. Über einige Originale Goepperts und neuere Funde. Jahrb. Preuß. Geol. Landesanst., 40(1919), 1(3): 363–433.

KRÄUSEL R. & WEYLAND H. 1954. Kritische Untersuchungen zur Kutikularanalyse tertiärer Blätter 2. Palaeontographica, B, 96: 106–163.

KRÄUSEL R. & WEYLAND H. 1959. Kritische Untersuchungen zur Kutikularanalyse tertiärer Blätter 4. Palaeontographica, B, 105: 101–124.

KVAČEK Z. 2003. Aquatic Angiosperms of the Early Miocene Most Formation of North Bohemia (Central Europe). Cour. Forsch.-Inst. Senckenberg, 241: 255–279.

KVAČEK Z. 2006. Fossil fruits of *Reevesia* (Malvaceae, subfam. Helicteroideae) and associated plant organs (seeds, foliage) from the Lower Miocene of North Bohemia (Czech Republic). N. Jb. Geol. Palaeont. Mh., 2006(7): 431–448.

KVAČEK Z. & HABLY L. 1991. Notes on the Egerian stratotype flora at Eger (Wind brickyard), Hungary, Upper Oligocene. Ann. Hist. Nat. Mus. Natn. Hung., 83: 49–82.

KVAČEK Z. & HOLÝ F. 1974. *Alnus julianaeformis* (Sternberg 1823) comb. n., a noteworthy Neogene alder. Čas. Mineral. Geol., 19(4): 367–372.

KVAČEK Z. & HURNÍK S. 2000. Revision of Early Miocene plants preserved in baked rocks in the North Bohemian Tertiary. Acta Mus. Nat. Pragae, Ser. B, Hist. Nat., 56(1–2): 1–48.

KVAČEK Z. & KONZALOVÁ M. 1996. Emended characteristics of *Cercidiphyllum crenatum* (Unger) R.W. Brown based on reproductive structures and pollen in situ. Palaeontographica, B, 239(4–6): 147–155.

KVAVADZE E.V. & CONNOR S.E. 2005. *Zelkova carpinifolia* (Pallas) K. Koch in Holocene sediments of Georgia - an indicator of climatic optima. Rev. Palaeobot. Palynol., 133: 69–89.

ŁAŃCUCKA-ŚRODONIOWA M. 1957. Mioceńska flora z Rypina na Pojezierzu Dobrzyńskim (summary: Miocene flora at Rypin in Dobrzyń Lake District). Pr. Inst. Geol., 15: 5–76.

ŁAŃCUCKA-ŚRODONIOWA M. 1965. Wstępne wyniki badań paleobotanicznych nad neogenem Domańskiego Wierchu i Orawy (summary: Preliminary results of palaeobotanical investigations of fresh-water deposits of Domański Wierch and Orawa). Roczn. Pol. Tow. Geol., 35(8): 362–365; 409–410.

ŁAŃCUCKA-ŚRODONIOWA M. & ZASTAWNIAK E. 1997. The Middle Miocene flora of Wieliczka revision of Jan Zabłocki's collection. Acta Palaeobot., 37(1): 17–49.

ŁAŃCUCKA-ŚRODONIOWA M., WALTHER H. & ZASTAWNIAK E.1981. A preliminary report on a new study of the Neogene flora from Sośnica near Wrocław in Lower Silesia, West Poland (leaf and fruit-seed floras). Acta Palaeobot., 21(2): 101–114.

MAI D.H. 1995. Tertiäre Vegetationsgeschichte Europas. Gustav Fischer Verlag. Jena, Stuttgart, New York.

MAI D.H. & GREGOR H.-J. 1982. Neue und interessante Arten aus dem Miozän von Salzhausen im Vogelsberg. Feddes Repert., 93(6): 405–435.

MAI D.H. & WALTHER H. 1978. Die Floren der Haselbacher Serie im Weisselster-Becken (Bezirk Leipzig, DDR). Abh. Staatl. Mus. Mineral. Geol. Dresden, 28: 1–200.

MAI D.H. & WALTHER H. 1991. Die oligozänen und untermiozänen Floren Nordwest-Sachsens und des Bitterfelder Raumes. Abh. Staatl. Mus. Mineral. Geol. Dresden, 38: 1–230.

MANCHESTER S.R. 1987. The fossil history of the Juglandaceae. Miss. Bot. Garden Monograph, 21: 1–137.

MENZEL P. 1910. Pflanzenreste aus dem Posener Ton. Jahrb. Preuß. Geol. Landesanst., 31(1–1): 173–191.

MEYER F. 1919. Salicaceen, Aceraceen und die übrigen nachgewiesenen Pflanzenreste. In: Kräusel R. Die Pflanzen des schlesischen Tertiärs. Jahrb. Preuß. Geol. Landesanst., 38 (1917), 1(2): 145–184.

MOORE P.D., WEBB J.A. & COLLINSON M.E. 1991. Pollen analysis. Blackwell Scientific Publications, Oxford.

OBERC J. & DYJOR S. 1969. Uskok sudecki brzeżny. Biul. Państw. Inst. Geol., 236: 41–193.

PAX F. 1907. Fossile Pflanzen von Trebnitz. Jahresber. Schles. Ges. Vaterl. Kult., 84: 53–56.

PETERS I. 1963. Die Flora der Oberpfälzer Braunkohlen und ihre ökologische und stratigraphische Bedeutung. Palaeontographica, B, 112: 1–50.

PROCHÁZKA M. & BŮŽEK Č. 1975. Maple leaves from the Tertiary of North Bohemia. Rozpr. Ústř. Úst. Geol., 41: 1–86.

RANIECKA-BOBROWSKA J. 1954. Trzeciorzędowa flora liściowa z Konina (summary: Tertiary foliaceous flora from Konin). Biul. Inst. Geol., 71: 5–36.

RANIECKA-BOBROWSKA J. 1957. Kilka szczątków roślinnych z tortonu Górnego Śląska (summary: A few plant remnants from the Tortonian of Upper Silesia). Kwart. Geol., 1(2): 275–297.

RANIECKA-BOBROWSKA J. 1962. Trzeciorzędowa flora z Osieczowa nad Kwisą – Dolny Śląsk (summary: Tertiary flora from Osieczów on the Kwisa river – Lower Silesia). Pr. Inst. Geol., 30(3): 81–223.

RANIECKA-BOBROWSKA J. 1970. Stratygrafia młodszego trzeciorzędu Polski na podstawie badań paleobotanicznych (summary: Stratigraphy of Late Tertiary in Poland on the basis of palaeobotanical research). Kwart. Geol., 14(4): 728–753.

RASTIN N. 1983. Vegetationskundliche Untersuchungen in Hochwaldresten der Kaspischen Ebene. Phytocoenologia, 11: 245–289.

REIMANN H. 1919. Betulaceen und Ulmaceen. In: Kräusel R. Die Pflanzen des schlesischen Tertiärs. Jahrb. Preuß. Geol. Landesanst., 38(1917), 1(2): 4–96.

SAKALA J. 2000. Flora and vegetation of the roof of the main lignite seam in the Bílina Mine (Most Basin, Lower Miocene). Acta Mus. Nat. Pragae, Ser. B, Hist. Nat., 56(1–2): 49–84.

SAPORTA G. 1865. Études sur la végétation du Sud-Est de la France à l'époque Tertiaire. Ann. Sci. Nat. Bot. Ser., 5(4): 5–264.

SATERNUS. A. 1995. Budowa strukturalna południowej części legnickiego kompleksu złóż węglowych. In: Lipiarski I. (ed.) Materiały XVIII Sympozjum „Geologia Formacji Węglonośnych Polski", AGH, Kraków, 5–6 kwietnia 1995. Wyd. AGH, Kraków: 60.

SCHIMPER W.P. 1870–1872. Traité de paléontologie végétale. 2. J.B. Baillière et Fils. Paris.

SCHLECHTENDAL D. H. R. 1897. Beiträge zur näheren Kenntnis der Braunkohlenflora Deutschlands. Abh. Naturf. Ges. Halle, 21(1–3): 85–110.

SCHNEIDER W. 1969. Cuticulae dispersae aus dem 2. Lausitzer Flöz (Miozän) und ihre fazielle Aussage. Freiberger Forschh.-H. C, 222: 1–75.

SCHNEIDER W. 1992. Floral Successions in Miocene Swamps and Bogs of Central Europe. Z. Geol. Wiss., 20(5–6): 555–570.

SCHNEIDER W. 2004. Eine blätterführende Taphocoenose im 2. Miozänen Flöz von Nochten (Lausitz): Taxonomie, Taphonomie und Phytostratigraphie Palaeontographica, B, 268: 1–74.

SHVAREVA N.Ya. 1983. Miotsenovaya flora Predkarpat'ya. Naukova Dumka. Kiev.

SITÁR V. & TAKAČ M. 1993. Neogene flora of Nováky Coal Basin, locality Lehota pod Vtáčnikom. Acta Geol. Univ. Comenianae, 49: 63–96.

STERNBERG K.M. 1823. Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt. 3. Fr. Fleischer, Leipzig, Ernst Breck's Witwe, Regensburg, J. Spurny, G. Hässe Söne, Prag.

STERNBERG K. 1838. Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt. 7–8. Fr. Fleischer, Leipzig, Ernst Breck's Witwe, Regensburg, J. Spurny, G. Hässe Söne, Prag.

STIZENBERGER E. 1851. Übersicht der Versteinerungen des Grossherzogtums Baden. J. Diernfellner, Freiburg.

STUCHLIK L., SZYNKIEWICZ A., ŁAŃCUCKA-ŚRODONIOWA M. & ZASTAWNIAK E. 1990. Wyniki dotychczasowych badań paleobotanicznych trzeciorzędowych węgli brunatnych złoża „Bełchatów" (summary: Results of the hitherto palaeobotanical investigations of the Tertiary brown coal bed „Bełchatów", Central Poland). Acta Palaeobot., 30(1–2): 259–305.

SVESHNIKOVA I.N. 1963. Opredelitel' sovremennykh i iskopaemykh predstaviteley Sciadopityaceae i Taxodiaceae po epiderme list'ev (summary: Atlas and key for the identification of the living and fossil Sciadopityaceae and Taxodiaceae based on the structure of the leaf epiderm). Trudy Bot. Inst. Komarov Akad. Nauk SSSR, Ser. Paleobotanika, 4: 205–229.

SZAFER W. 1961. Mioceńska flora ze Starych Gliwic na Śląsku (summary: Miocene flora from Stare Gliwice in Silesia). Pr. Inst. Geol., 33: 5–143.

TUTAYUK V.Kh. 1975. Drevesnye relikty Talysha. Anatomo-morfologicheskoe issledovanie. Akad. Nauk ASSR, Inst. Bot. im. Komarova. Izd. ELM, Baku.

UNGER F. 1841. Chloris protogaea. Beiträge zur Flora der Vorwelt, H. I. Wilhelm Engelmann., Leipzig.

UNGER F. 1847. Chloris protogaea. Beiträge zur Flora der Vorwelt. H. IV. Wilhelm Engelmann., Leipzig.

UNGER F. 1849. Blätterabdrücke aus dem Schwefelflötze von Swoszowice in Galizien. Haidinger Naturwiss. Abh., 3(1): 121–128.

UNGER F.1850a. Genera et species plantarum fossilium. W. Braumüller, Vindobona.

UNGER F. 1850b. Die Gattung *Glyptostrobus* in der Tertiär-Formation. Sitz. Ber. Akad. Wiss., Math.-Naturwiss., Cl., 5: 434–435.

UNGER F. 1852. Iconographia plantarum fossilium. Denkschr. Kaiserl. Akad. Wiss. Math.-Naturwiss., Cl., 4(1): 73–118.

UNGER F. 1861. Sylloge plantarum fossilium. Denkschr. Kaiserl. Akad. Wiss., Math.-Naturwiss., Cl., 19: 1–48.

USDA, NRCS, (2004) The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874–4490 USA.

WALTHER H. 1972. Studien über tertiäre *Acer* Mitteleuropas. Abh. Staatl. Mus. Mineral. Geol. Dresden, 19: 1–309.

WALTHER H. & ZASTAWNIAK E. 2005. Sapindaceae (Aceroideae) from the late Miocene flora of Sośnica near Wrocław – a revision of Göppert's original materials and a study of more recent collections. Acta Palaeobot. 45(1): 85–106.

WANG C. W. 1961. The forests of China with a survey of grassland and desert vegetation. Harward Univ. Publ., Maria Moors Cabot Found., Cambridge, Mass., 5: 1–313.

WATSON F.D. 1993. Taxodiaceae. Flora of North America Editorial Committee (eds.) Flora of North America North of Mexico, Vol. 2. Oxford University Press.

WAŻYŃSKA H. 1995. Wyniki analizy palinologicznej próbek z osadów mioceńskich z wiercenia Ruja 99/72 (arkusz Środa Śląska). In: Dyląg J.K. & Kasiński J.R. (eds) Poszukiwania złóż węgla brunatnego w Polsce: rejon Ruja, województwo legnickie. Państw. Inst. Geol., 50 p., Centr. Arch. Geol. Państw. Inst. Geol. 1489/25, Warszawa.

WEYLAND H. 1934. Beiträge zur Kenntnis der rheinischen Tertiärflora 1. Floren aus den Kieseloolith- und Braunkohlenschichten der Niederrheinischen Bucht. Abh. Preuß. Geol. Landesanst., 161: 1–122.

WILDE V., LENGTAT K.-H. & RITZKOWSKI S. 1992. Die oberpliozäne Flora von Willershausen am Harz von Adolf Straus (†). Ber. Naturhist. Ges. Hannover, 134: 7-115.

WILKINSON H.P. 1979. The plant surface (mainly leaf): 97–166. In: Metcalfe C.R. & Chalk L. (eds) Anatomy of the Dicotyledons. Second Edition, vol. 1. Clarendon Press, Oxford.

WOROBIEC G. 1994. Upper Miocene fossil plants from the outcrop of Stare Bystre (Western Carpathians, Poland). Acta Palaeobot., 34(1): 83–105.

WOROBIEC G. 1995. A preliminary report on the Lower Miocene leaf flora from the brown coal mine "Bełchatów" (Central Poland). Acta Palaeobot., 35(2): 243–251.

WOROBIEC G. 2003. New fossil floras from Neogene deposits in the Bełchatów Lignite Mine. Acta Palaeobot. Suppl., 3: 1–133.

WOROBIEC G. & FLORJAN S. 1997. Liście kopalne z otworu wiertniczego 1211/B w Kopalni Węgla Brunatnego "Bełchatów". Spraw. z Posiedzeń Kom. Nauk. PAN, oddział w Krakowie, 40(2): 153–156.

WOROBIEC G. & KASIŃSKI J. 2005. Plant macroremains from boreholes from "Ruja" lignite deposit near Legnica, Lower Silesia, Poland (preliminary results). Documenta Naturae, 155 (1): 1–11.

WOROBIEC G. & LESIAK M. 1998. Plant megafossils from the Neogene deposits of Stawek-1A (Bełchatów, Middle Poland). Rev. Palaeobot. Palynol., 101: 179–208.

WOROBIEC G., SZYNKIEWICZ A. 2007. Betulaceae leaves in Miocene deposits of the Bełchatów Lignite Mine (Central Poland). Rev. Palaeobot. Palynol., 147: 28–59.

WÓJCICKI J.J. & ZASTAWNIAK E. 1998. *Trapa srodoniana,* a new fossil species from the Pliocene of Bełchatów (Middle Poland). Acta Palaeobot., 38(1): 167–174.

WÓJCICKI J.J. & ZASTAWNIAK E. 2003. Rodzina Trapaceae w trzeciorzędzie Europy – wstępne wyniki badań (summary: The Trapaceae family in the Tertiary of Europe – preliminary results). Bot. Guidebooks, 26: 153–185.

ZABŁOCKI J. 1924. Trzeciorzędowa flora z Chodzieży – La flore tertiaire de Chodzież (Posnanie). Bull. Acad. Pol. Sci., Sér. Biol., (5–6): 399–406.

ZALEWSKA Z. 1959. Coniferae: Taxodiaceae. In: Czeczott H. (ed.) Flora kopalna Turowa kolo Bogatyni (summary: Coniferae: Taxodiaceae. The fossil flora of Turów near Bogatynia). Pr. Muz. Ziemi, 3: 69–92, 115–120.

ZASTAWNIAK E. 1972. Pliocene leaf flora from Domański Wierch near Czarny Dunajec (Western Carpathians, Poland). Acta Palaeobot., 13(1): 3–73.

ZASTAWNIAK E. 1980. Sarmatian leaf flora from the southern margin of the Holy Cross Mts. (South Poland). Pr. Muz. Ziemi, 33: 39–108.

ZASTAWNIAK E. & WALTHER H. 1998. Betulaceae from Sośnica near Wrocław (Poland) – a revision of Goeppert's original materials and study of more recent collections. Acta Palaeobot., 38(1): 87–145.

ZASTAWNIAK E., ŁAŃCUCKA-ŚRODONIOWA M., BARANOWSKA-ZARZYCKA Z., HUMMEL A. & LESIAK M. 1996. Flora megasporowa, liściowa i owocowo-nasienna. In: Malinowska L. & Piwocki M. (eds) Budowa Geologiczna Polski, T. 3, Atlas Skamieniałości Przewodnich i Charakterystycznych, 3a, kenozoik, trzeciorzęd, neogen. Polska Agencja Ekologiczna, Warszawa: 855–940.

ZIEMBIŃSKA-TWORZYDŁO M. 1996. Flora sporowo-pyłkowa. In: Malinowska L. & Piwocki M. (eds) Budowa Geologiczna Polski, T. 3, Atlas Skamieniałości Przewodnich i Charakterystycznych, 3a, kenozoik, trzeciorzęd, neogen. Polska Agencja Ekologiczna, Warszawa: 797–855.

ZIEMBIŃSKA-TWORZYDŁO M. 1998. Climatic phases and spore-pollen zones. In: Ważyńska H. (ed.) Palynology and Palaeogeography of the Neogene in the Polish Lowlands. Prace Państw. Inst. Geol., 160: 12–16.

ZIEMBIŃSKA-TWORZYDŁO M., GRABOWSKA I., KOHLMAN-ADAMSKA A., SADOWSKA A., SŁODKOWSKA B., STUCHLIK L. & WAŻYŃSKA H. 1994. Checklist of selected genera and species of spores and pollen grains ordered in morphological system. In: Stuchlik L. (ed.) Neogene pollen flora of Central Europe. Part 1. Acta Palaeobot., Suppl., 1: 31–56.

PLATES

Plate 1

Osmunda parschlugiana (Unger) Andreánszky

1a. Detached leaflets, specimen No. KRAM-P 244/A/1
1b. Enlargement of leaflet, specimen No. KRAM-P 244/A/1

Taxodium dubium (Sternberg) Heer vel *Sequoia abietina* (Brongniart) Knobloch

2. Twigs, specimen No. KRAM-P 244/D/1/II

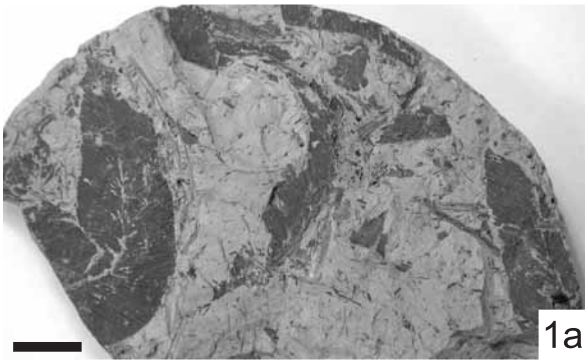
Glyptostrobus europaeus (Brongniart) Unger

3. Twigs, specimen No. KRAM-P 244/B/18
4. Cone, specimen No. KRAM-P 243/B/15
5. Isolated cone, specimen No. KRAM-P 243/E
7. Isolated twigs, specimen No. KRAM-P 244/C
8. Twigs, specimen No. KRAM-P 243/A/26/I

Sequoia abietina (Brongniart) Knobloch

6. Twig, specimen No. KRAM-P243/A/27

Scale bar – 1 cm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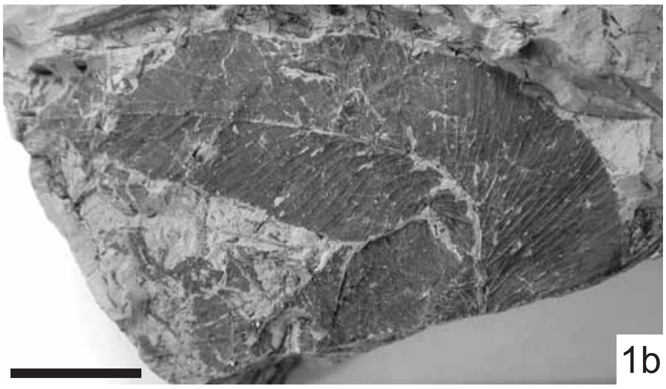
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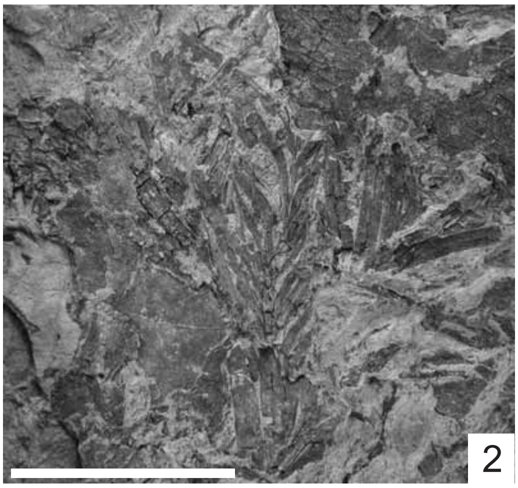
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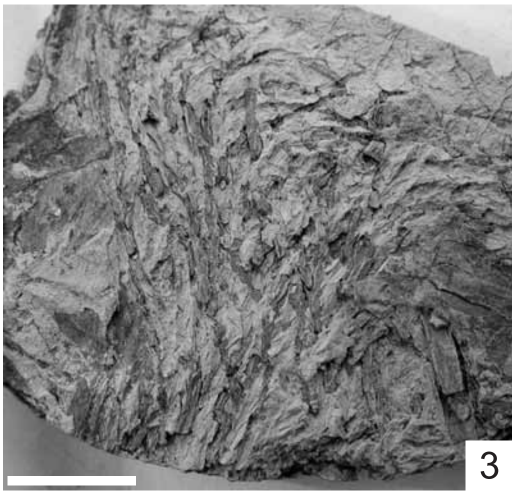
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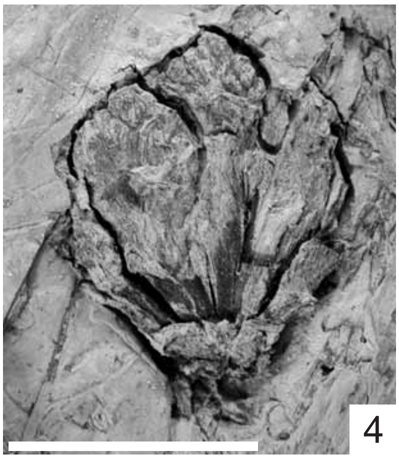
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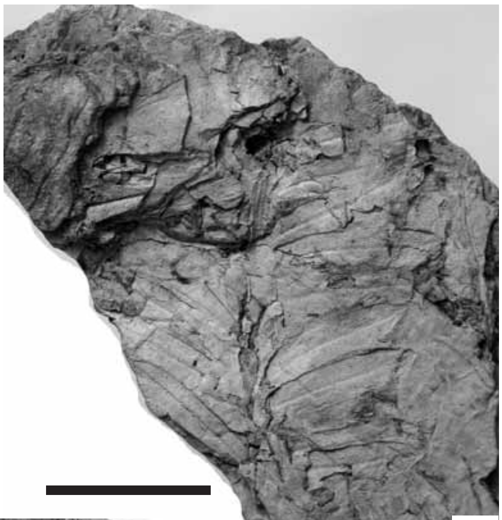
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Plate 2

Acer tricuspidatum Bronn *sensu* Procházka & Bůžek

1. Leaf, specimen No. KRAM-P 243/B/17
2. Leaf, specimen No. KRAM-P 244/B/2
5. Leaf, specimen No. KRAM-P 243/D/11/I

Acer sp. ex gr. Rubra Pax

3. Samara, specimen No. KRAM-P 243/C/5/IV
6. Samara, specimen No. KRAM-P 244/B/22/III

cf. *Carpinus grandis* Unger emend. Heer

4. Leaf, specimen No. KRAM-P 244/B/19/II

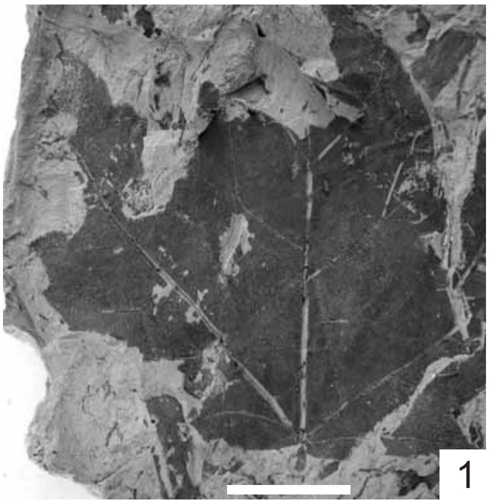
Acer sp.

7. Leaf, specimen No. KRAM-P 243/C/12/III

Alnus menzelii Raniecka-Bobrowska

8. Leaf, specimen No. KRAM-P 244/C/6

Scale bar – 1 cm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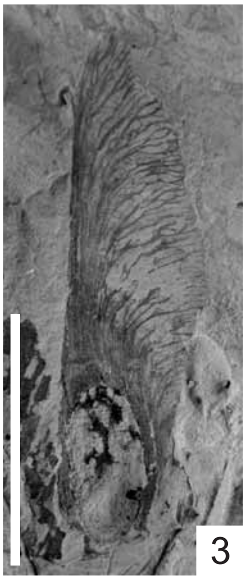
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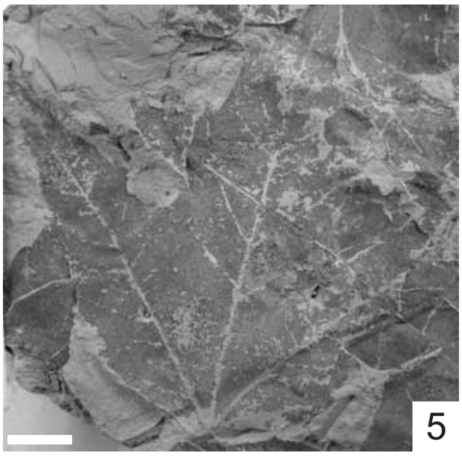
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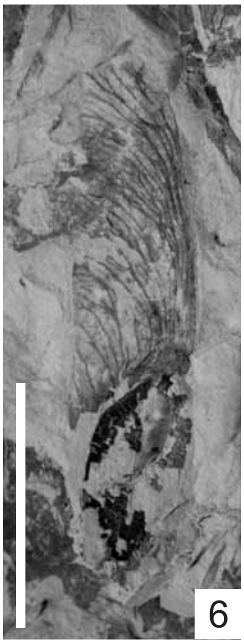
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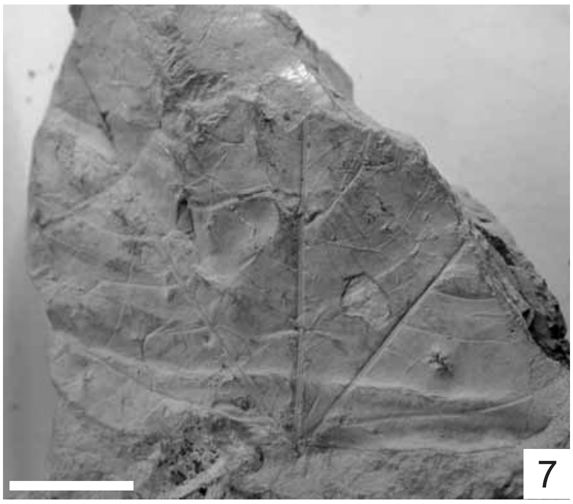
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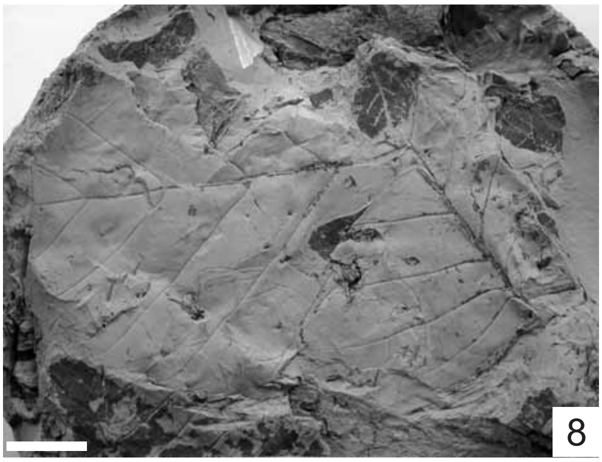
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Plate 3

Alnus menzelii Raniecka-Bobrowska

1. Leaf, specimen No. KRAM-P 244/B/8/II

„*Ficus*" *truncata* Heer *sensu* Bůžek

2. Leaf fragment, specimen No. KRAM-P 244/C/8/I

Byttneriophyllum tiliifolium (A. Braun) Knobloch & Z. Kvaček

3. Leaf, specimen No. KRAM-P 243/D/41
4. Leaf fragment with detail of leaf margin venation, specimen No. KRAM-P 243/D/38/I
5. Leaf, specimen No. KRAM-P 243/B/18/II

cf. „*Ficus*" *truncata* Heer *sensu* Bůžek

6. Fragment of destroyed leaf, specimen No. KRAM-P 243/D/27

Myrica lignitum (Unger) Saporta *sensu lato*

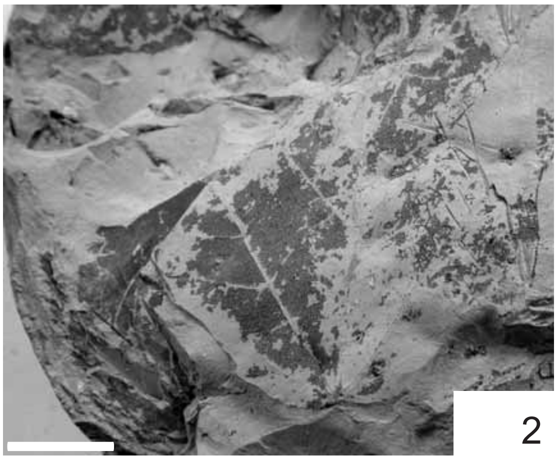
7. Leaf, specimen No. KRAM-P 244/B/34/I

cf. *Myrica lignitum* (Unger) Saporta *sensu lato*

8. Leaf, specimen No. KRAM–P 244/B/26/II

Scale bar – 1 cm


1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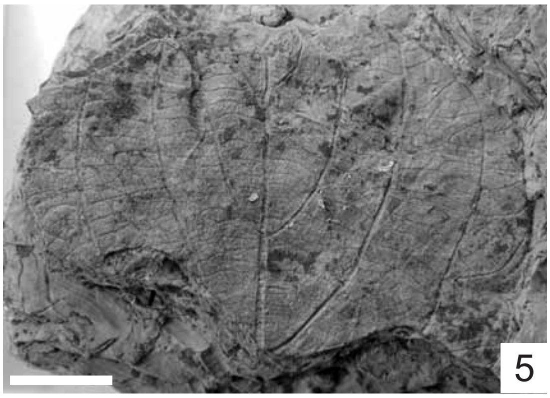
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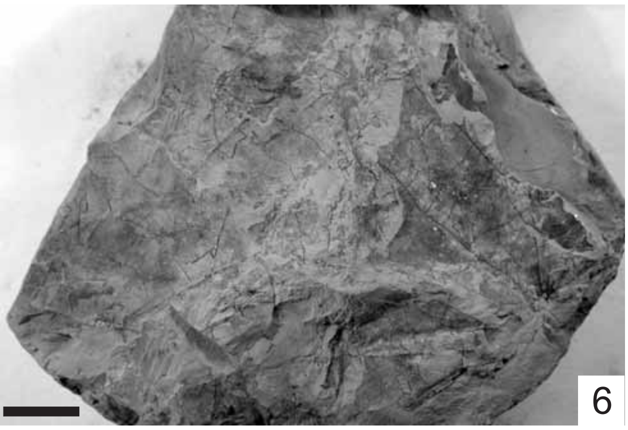
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Plate 4

Sprirematospennum wetzleri (Heer) Chandler

1. Seeds, specimen No. KRAM-P 244/C/28

Salix sp. 1

2. Leaf, specimen No. KRAM-P 243/A/11/I

Salix varians Goeppert *sensu lato*

3. Leaf, specimen No. KRAM-P 244/B/40/I
5. Leaf, specimen No. KRAM-P 243/C/1

Salix hausruckensis Kovar-Eder

4. Leaf, specimen No. KRAM-P 243/B/7
6. Detail of leaf margin, specimen No. KRAM-P 243/B/34

Pterocarya paradisiaca (Unger) Ilinskaya

7. Leaflet, specimen No. KRAM-P 243/D/3/III

Salix cf. *kicktonii* Weyland

8. Leaf, specimen No. KRAM-P 244/B/34/II

Zingiberoideophyllum liblarense Kräusel & Weyland

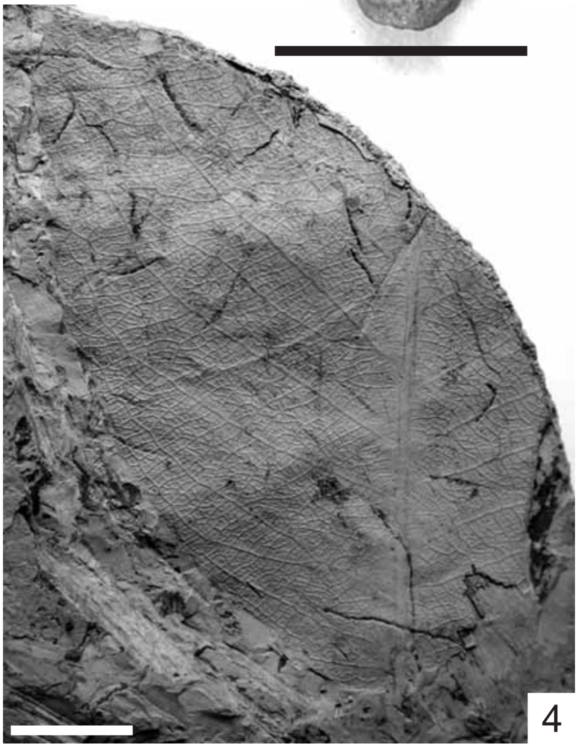
9. Fragment of leaf, specimen No. KRAM-P 244/C/21

Scale bar: 1 – 0.5 cm, 2–9 – 1 cm


1


2


3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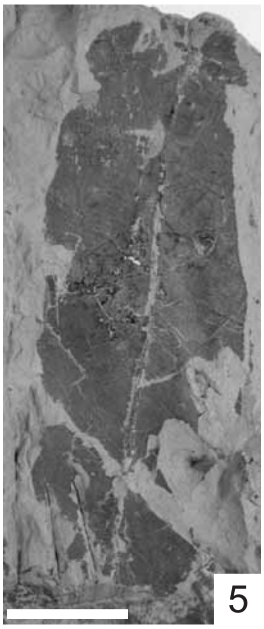
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Plate 5

Nyssa ornithobroma Unger

1. Seeds, specimen No. KRAM-P 244/C/27

Zelkova zelkovifolia (Unger) Bůžek & Kotlaba

2. Leaf fragment, specimen No. KRAM-P 244/B43

„Castanea" kubinyii Kováts ex Ettingshausen *sensu* Knobloch & Z. Kvaček

3. Leaf, specimen No. KRAM-P 243/D/8/II

Ulmus cf. *ruszovensis* Hummel

4. Leaf, specimen No. KRAM-P 243/D/3/II

Ulmus sp.

5. Leaf, specimen No. KRAM-P 244/B/6/I
7. Leaf, specimen No. KRAM-P 244/C/3/I

Ulmus pseudopyramidalis Z. Kvaček & Hably

6. Leaf, specimen No. KRAM-P 244/B/22/II

Dicotylophyllum sp. 2

8. Leaf, specimen No. KRAM-P 244/C/3/II

Scale bar – 1 cm


1


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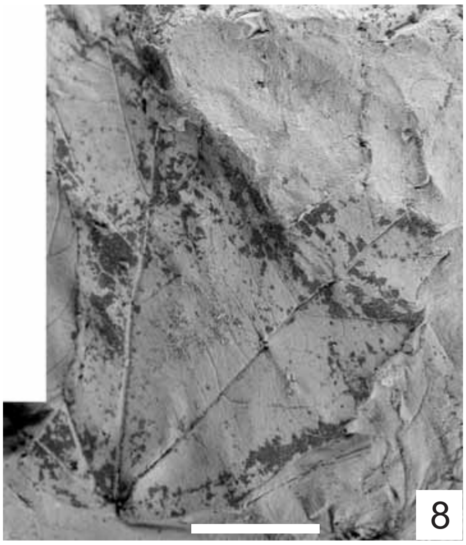
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Plate 6

cf. *Populus* sp.

1. Leaf, specimen No. KRAM-P 244/B/16

Populus populina (Brongniart) Knobloch

2. Leaf fragment with detail of leaf margin venation, specimen No. KRAM-P 244/B/6/II

Cercidiphyllum (?) *crenatum* (Unger) R. W. Brown emend. Z. Kvaček & Konzalová

3a. Leaf, specimen No. KRAM-P 244/C/12/I
3b. Detail of leaf margin, specimen No. KRAM-P 244/C/12/I

Dicotyledones indeterminatae

4. Leaf, specimen No. KRAM-P 244/B/28/II

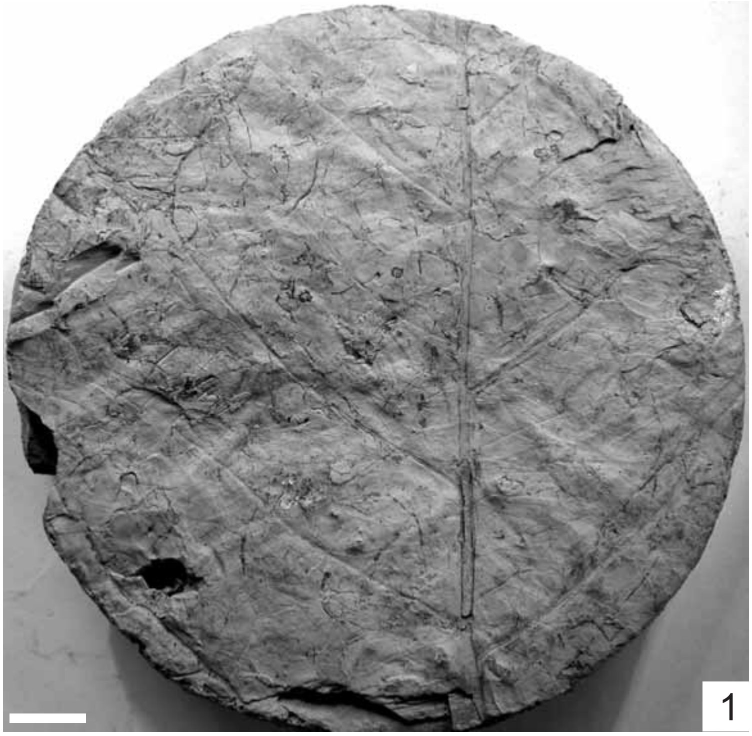
Incertae sedis

5. Specimen No. KRAM-P 244/B/25/II

Phragmites oeningensis A. Braun

6. Fragment of leaf, specimen No. KRAM-P 244/B/26/I

Scale bar – 1 cm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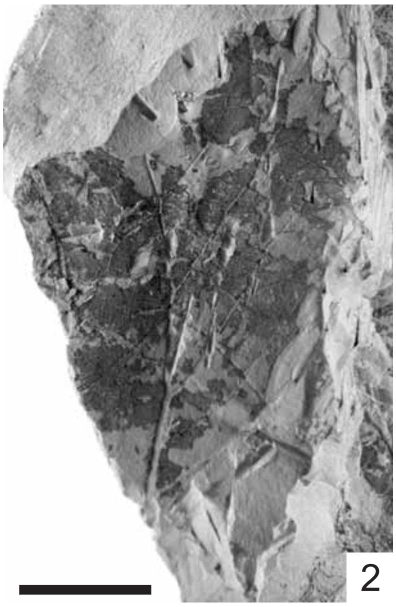
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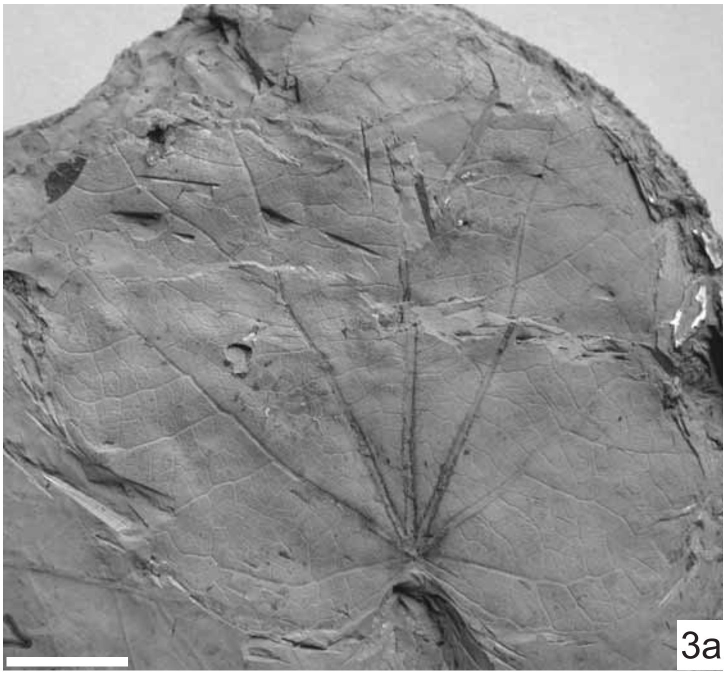
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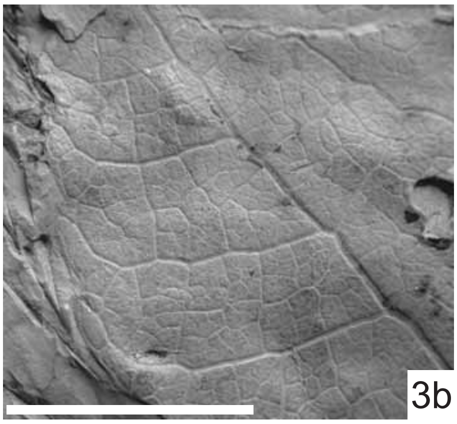
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Plate 7

Alnus menzelii Raniecka-Bobrowska

1. Detail of higher order venation of leaf, specimen No. KRAM-P 244/C/20/II

Byttneriophyllum tiliifolium (A. Braun) Knobloch & Z. Kvaček

2. Detail of higher order venation of leaf, specimen No. KRAM-P 243/B/18/II

Cercidiphyllum (?) *crenatum* (Unger) R. W. Brown emend. Z. Kvaček & Konzalová

3. Detail of higher order venation of leaf, specimen No. KRAM-P 244/C/12/I

„Castanea" kubinyii Kováts ex Ettingshausen *sensu* Knobloch & Z. Kvaček

4. Detail of higher order venation of leaf, specimen No. KRAM-P 243/D/10

Phragmites oeningensis A. Braun

5. Detail of higher order venation of leaf, specimen No. KRAM-P 244/B/26/I

Zingiberoideophyllum liblarense Kräusel & Weyland

6. Detail of higher order venation of leaf, specimen No. KRAM-P 244/C/21

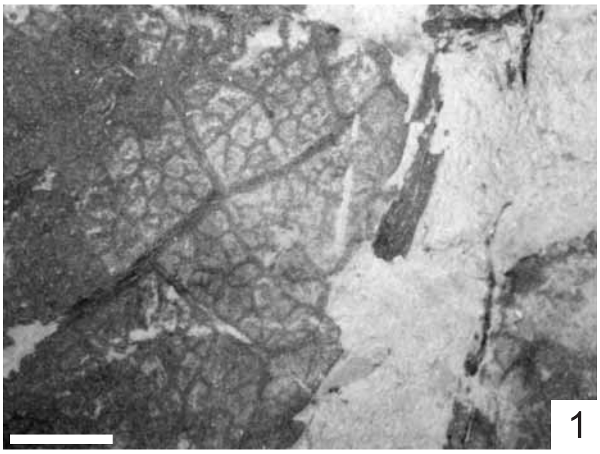
Hydrocharitaceae Jussieu gen. indet.

7. Detail of higher order venation of leaf, specimen No. KRAM-P 244/C/19/I

Cyperacites sp.

8. Detail of higher order venation of leaf, specimen No. KRAM-P 243/C/3/II

Scale bar – 1 mm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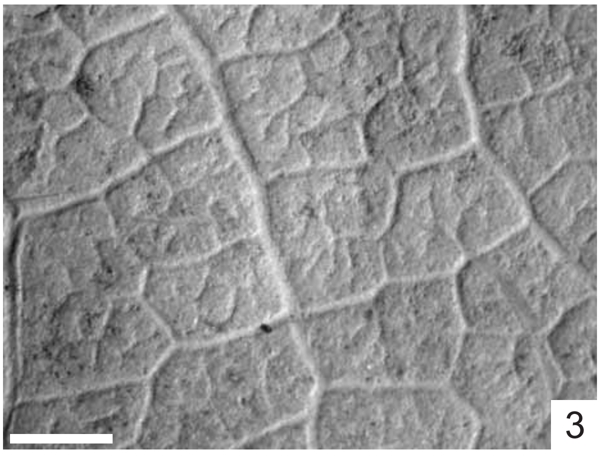
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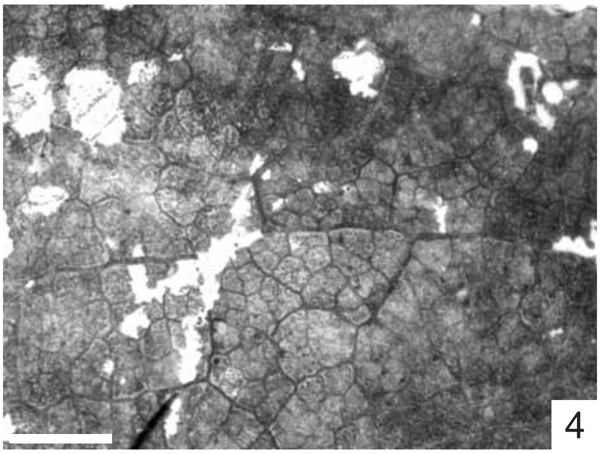
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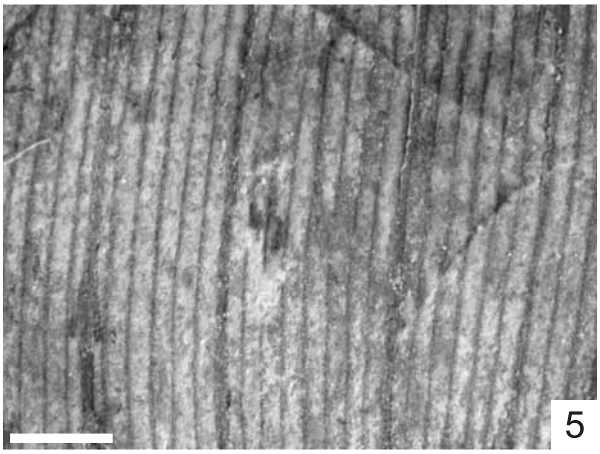
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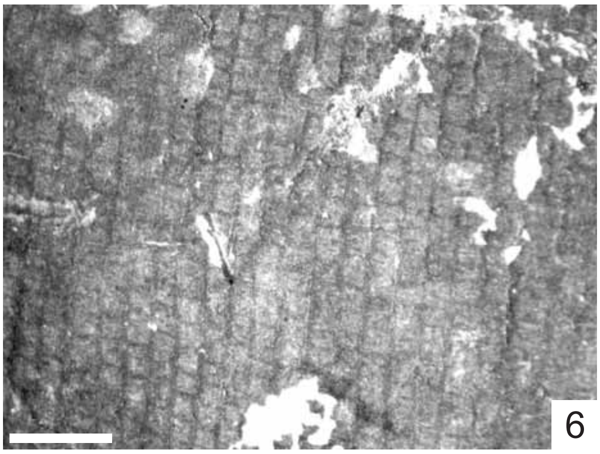
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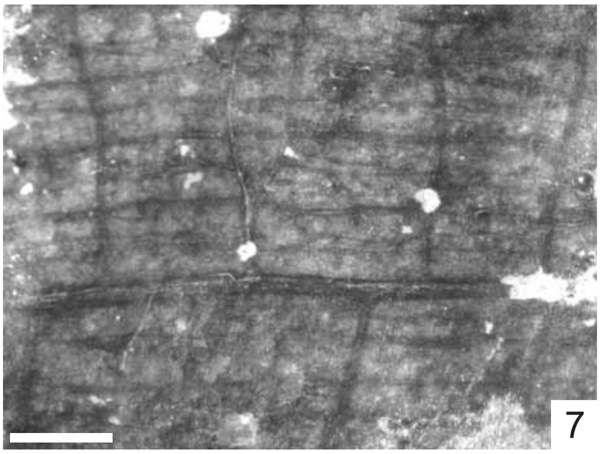
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Plate 8

Osmunda parschlugiana (Unger) Andreánszky

1. Epidermis with stomata, specimen No. KRAM-P 243/A/22
2. Trichomes on the epidermis, specimen No. KRAM-P 243/A/9

Glyptostrobus europaeus (Brongniart) Unger

3. Epidermis with stomata, specimen No. KRAM-P 243/A/26/I
4. Epidermis with stomata, visible considerably short epidermal cells, specimen No. KRAM-P 243/B/13
5. Epidermis with stomata, specimen No. KRAM-P 244/C/1/I

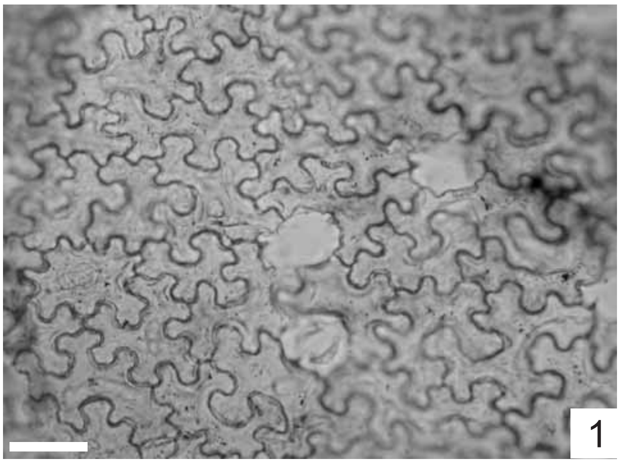
Sequoia abietina (Brongniart) Knobloch

6a. Epidermis composed of strongly elongated epidermal cells, specimen No. KRAM-P 243/A/5/I

6b. Epidermis with stomata arranged in parallel rows, specimen No. KRAM-P 243/A/5/I

6c. Hypodermal cells (short and rectangular with thin cell walls) and outlines of epidermal cells (elongated and thick cell walls), specimen No. KRAM-P 243/A/5/I

Scale bar – 50 µm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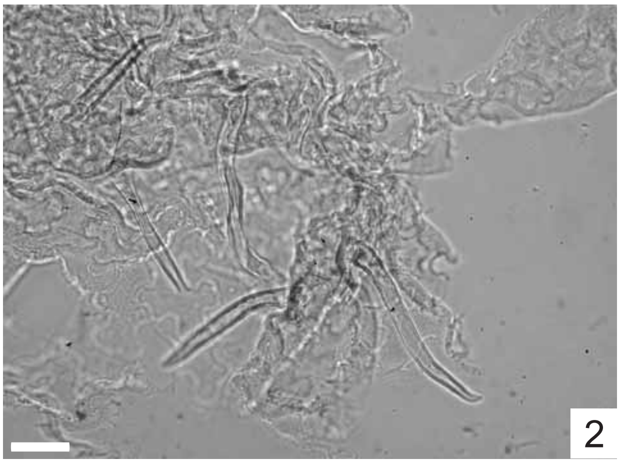
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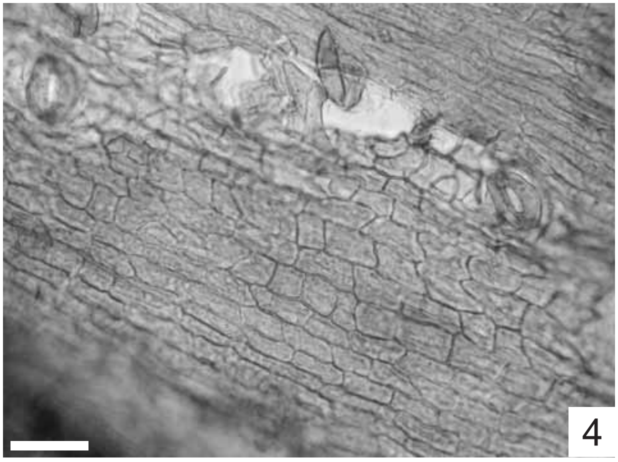
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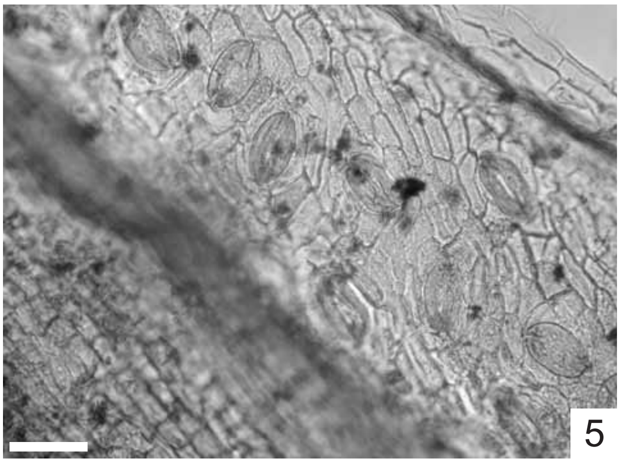
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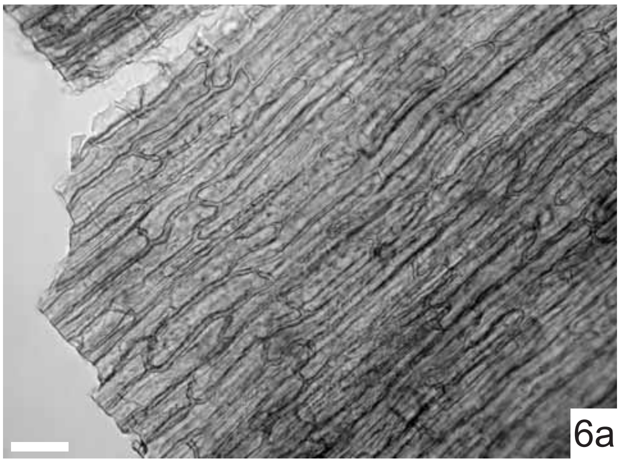
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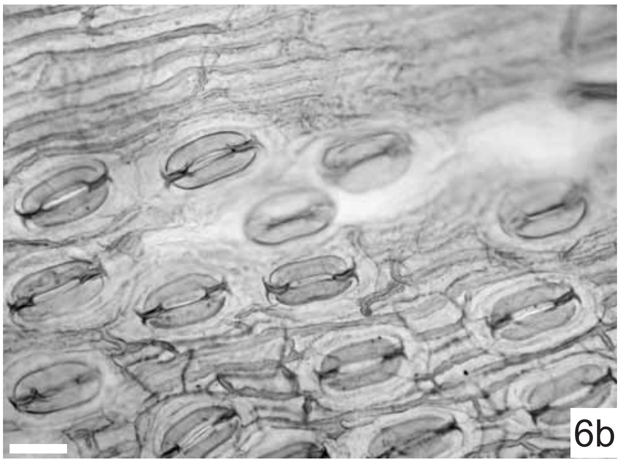
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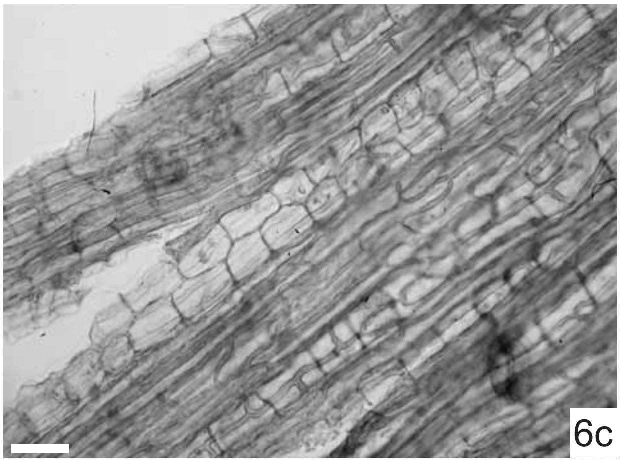
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Plate 9

Sequoia abietina (Brongniart) Knobloch

1. Epidermis, stomata irregularly arranged, specimen No. KRAM-P 243/A/5/I
2. Detail of stomata structure, specimen No. KRAM-P 243/A/12

Acer tricuspidatum Bronn *sensu* Procházka & Bůžek

3a. Adaxial epidermis, specimen No. KRAM-P 243/D/11/II
3b. Abaxial epidermis with stomata and trichomes, specimen No. KRAM-P 243/D/11/II
4a. Abaxial epidermis with stomata and trichomes, specimen No. KRAM-P 243/D/11/I
4b. Unicellular trichomes, specimen No. KRAM-P 243/D/11/I

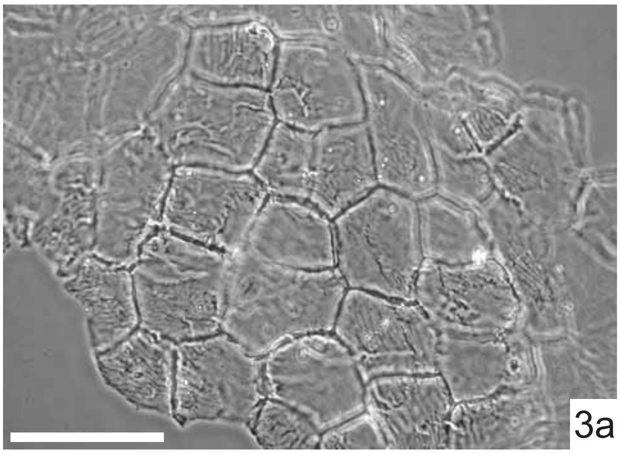
Alnus julianiformis (Sternberg) Z. Kvaček & Holý

5a. Adaxial epidermis, specimen No. KRAM-P 243/B/14
5b. Abaxial epidermis with stomata, specimen No. KRAM-P 243/B/14

Scale bar – 50 µm


1


2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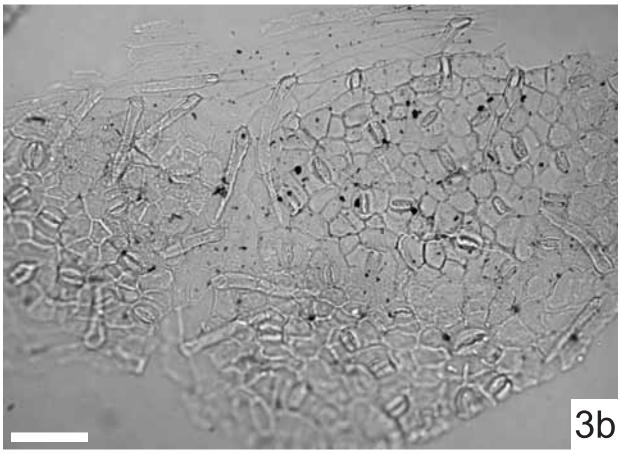
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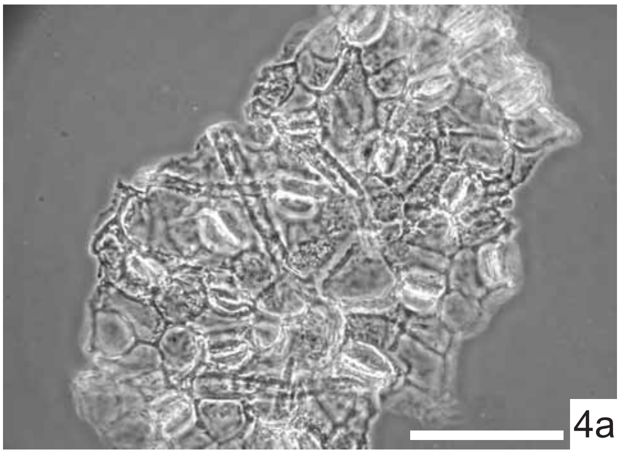
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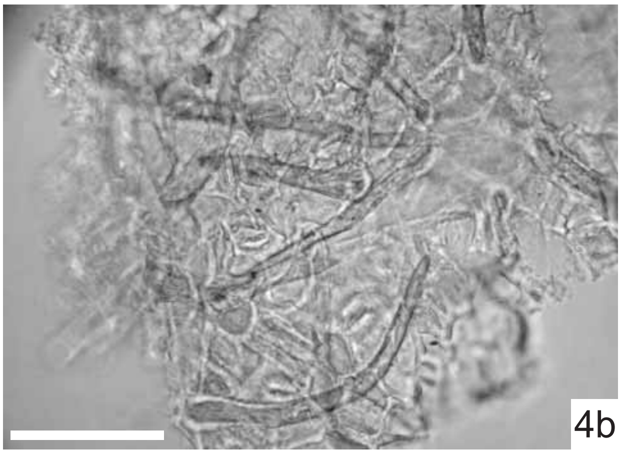
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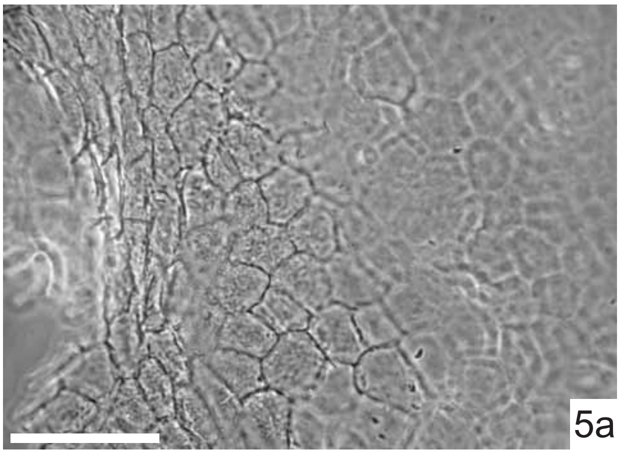
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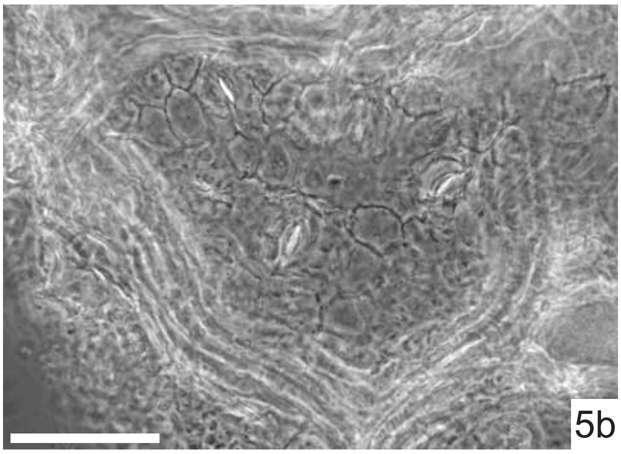
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Plate 10

Alnus julianiformis (Sternberg) Z. Kvaček & Holý

1a. Peltate glandular trichome on the abaxial epidermis, specimen No. KRAM-P 243/B/32
1b. Four-celled base of peltate glandular trichome, specimen No. KRAM-P 243/B/32

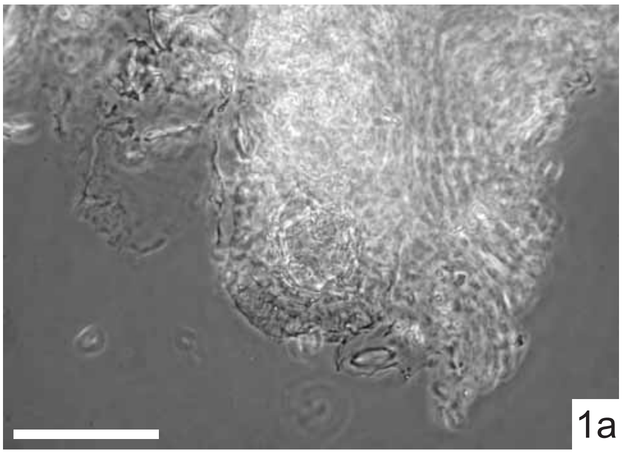
Alnus menzelii Raniecka-Bobrowska

2a. Adaxial epidermis with cuticular striations, specimen No. KRAM-P 243/B/20
2b. Abaxial epidermis with stomata, specimen No. KRAM-P 243/B/20
3. Four-celled base of peltate glandular trichome, specimen No. KRAM-P 244/C/10
4. Multicellular solitary trichome, possibly structural element of domatium, specimen No. KRAM-P 244/C/18

Byttneriophyllum tiliifolium (A. Braun) Knobloch & Z. Kvaček

5. Adaxial epidermis, specimen No. KRAM-P 244/C/16/I
6. Adaxial epidermis with cuticular ornamentation (reticulum), specimen No. KRAM-P 243/D/2/I

Scale bar – 50 µm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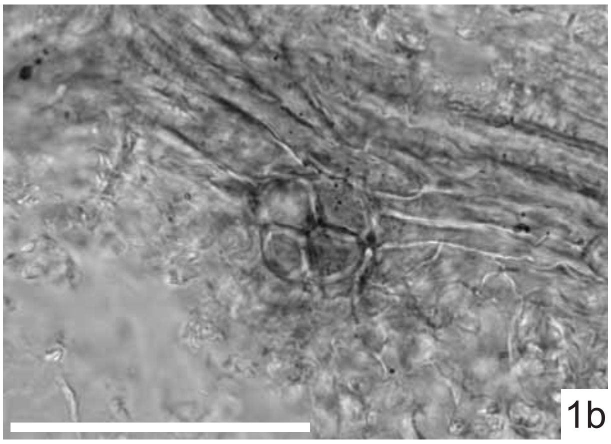
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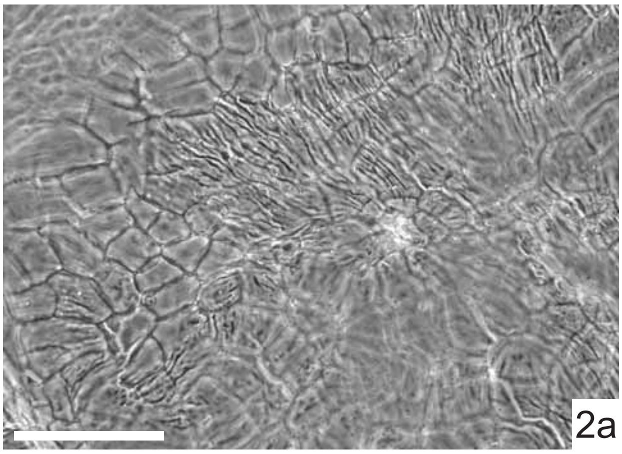
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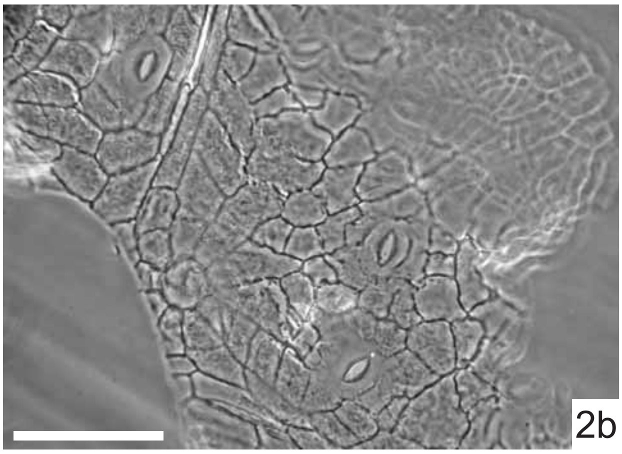
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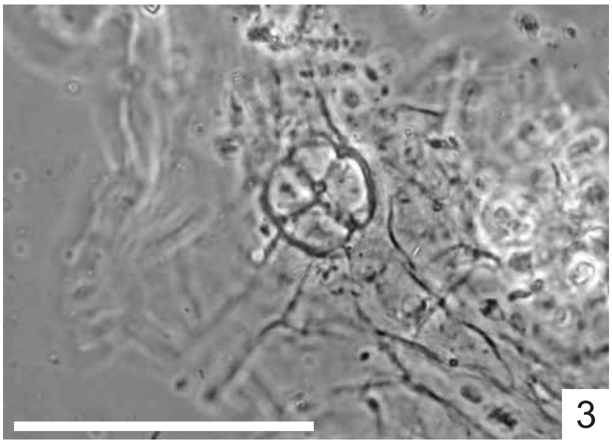
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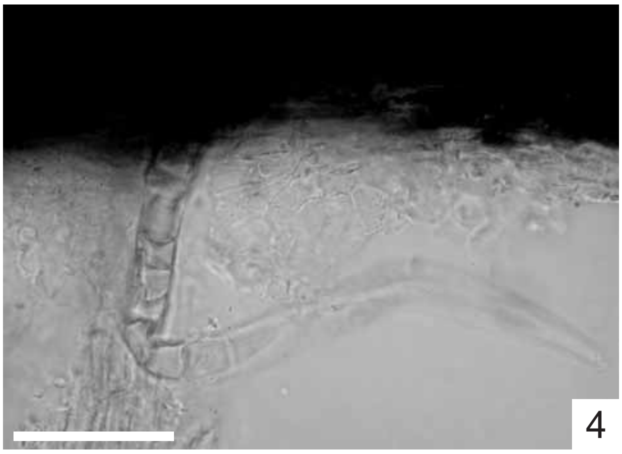
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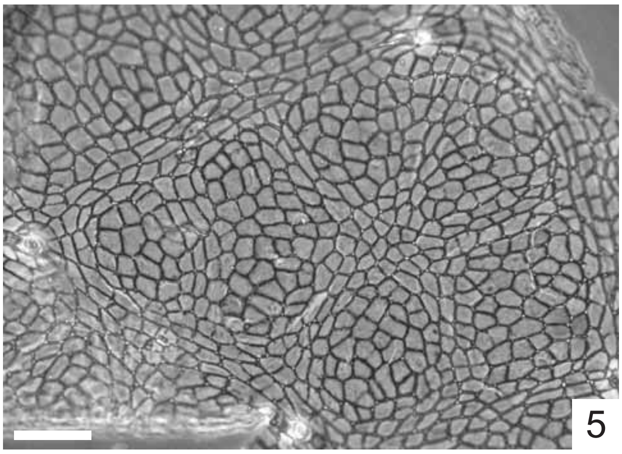
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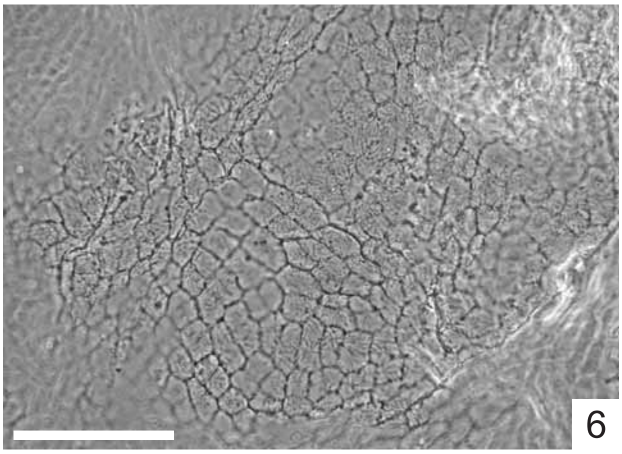
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Plate 11

Byttneriophyllum tiliifolium (A. Braun) Knobloch & Z. Kvaček

1. Abaxial epidermis with stomata and dense cover of stellate trichomes, specimen No. KRAM-P 244/D/2/I
2a. Abaxial epidermis with stomata, specimen No. KRAM-P 244/C/16/I
2b. Glandular, clavate trichome, specimen No. KRAM-P 244/C/16/I
3. Stellate trichome (A) and glandular clavate trichomes (B), specimen No. KRAM-P 243/B/24

„*Ficus*” *truncata* Heer sensu Bůžek

4a. Four-celled glandular clavate trichomes, specimen No. KRAM-P 244/C/8/I
4b. Adaxial epidermis, specimen No. KRAM-P 244/C/8/I
4c. Abaxial epidermis with stomata and base of stellate trichome, specimen No. KRAM-P 244/C/8/I

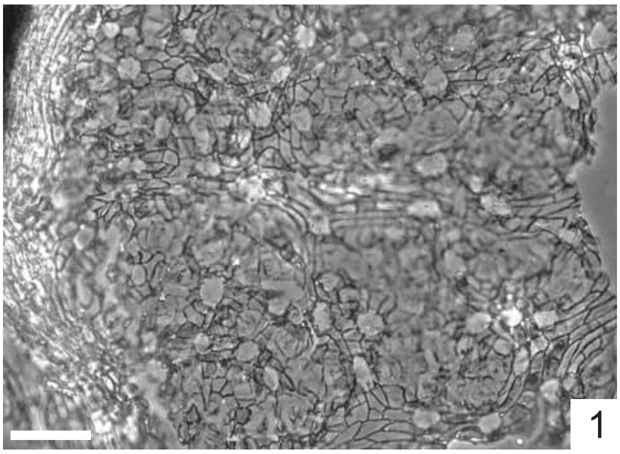
Fungal fruiting body detached from the epidermis of *Cercidiphyllum* (?) *crenatum* (Unger) R. W. Brown emend. Z. Kvaček & Konzalová

5a. Specimen No. KRAM-P 244/C/12/I

Cercidiphyllum (?) *crenatum* (Unger) R. W. Brown emend. Z. Kvaček & Konzalová

5b. Adaxial epidermis, specimen No. KRAM-P 244/C/12/I

Scale bar – 50 µm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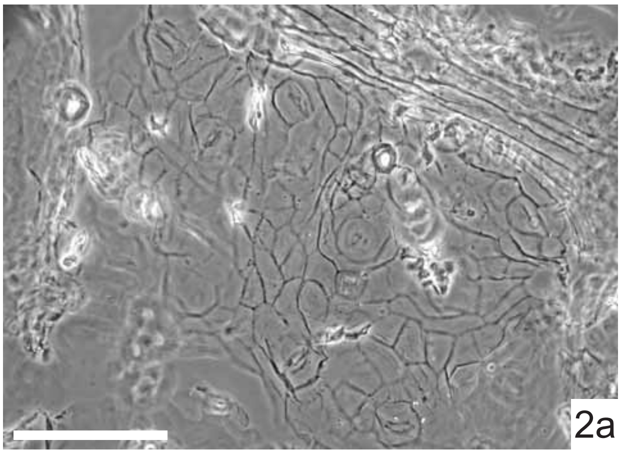
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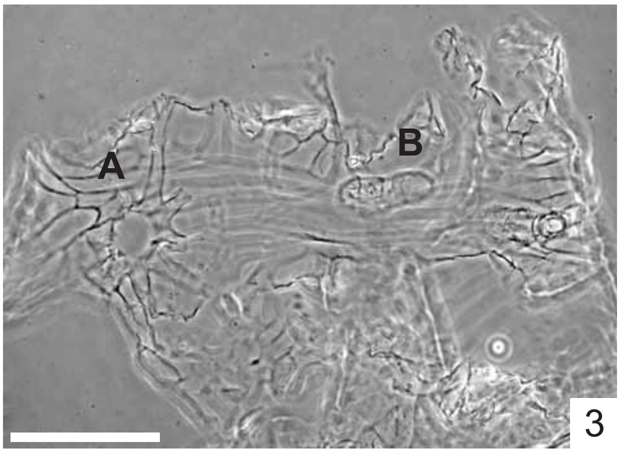
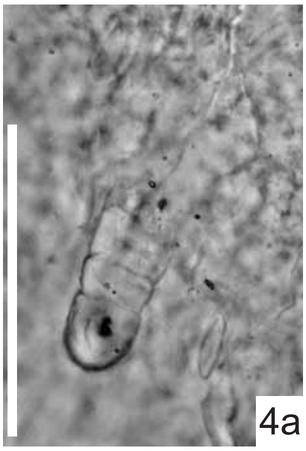

A
B
3


2b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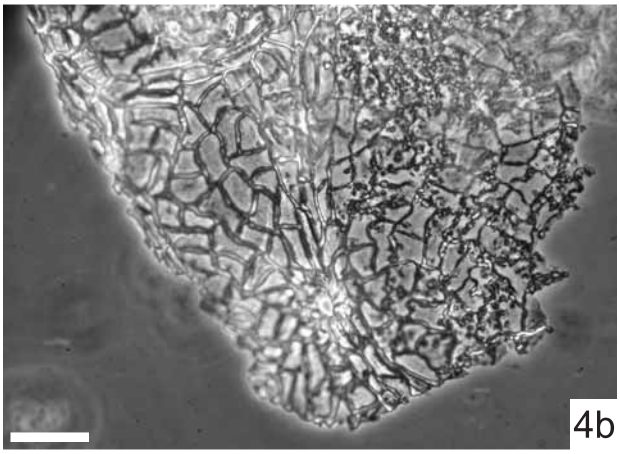
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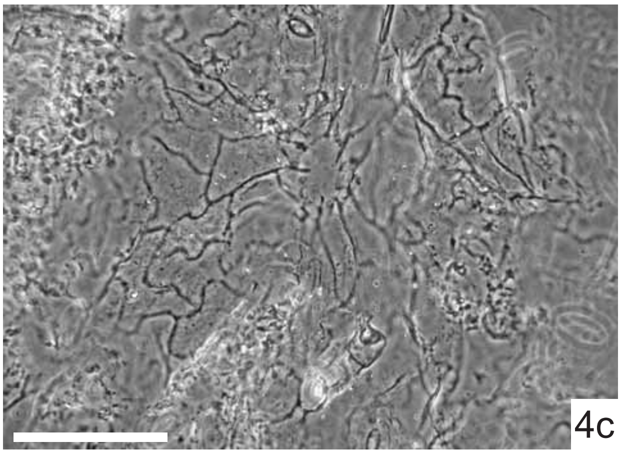
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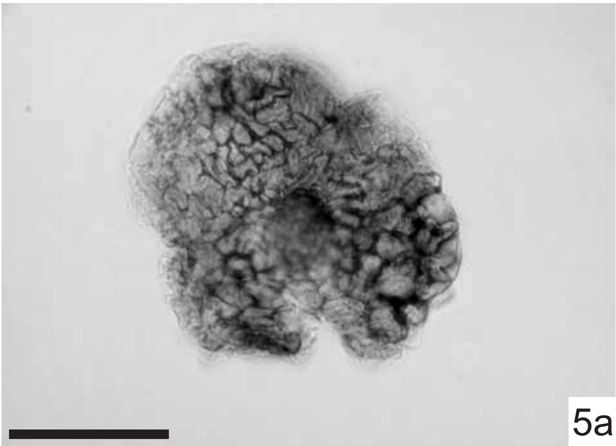
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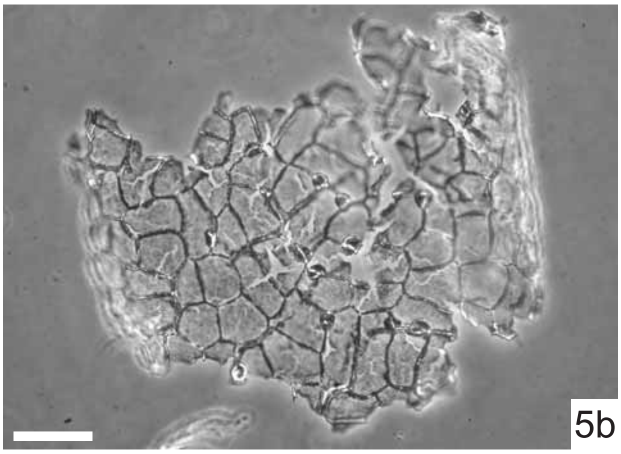
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Plate 12

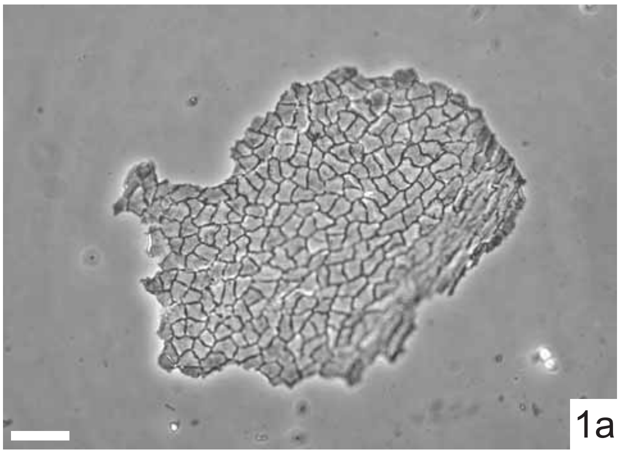
Myrica lignitum (Unger) Saporta *sensu lato*

1a. Adaxial epidermis, specimen No. KRAM-P 243/A/2
1b. Abaxial epidermis with stomata and peltate glandular trichomes, specimen No. KRAM-P 243/A/2
1c. Abaxial epidermis with stomata and peltate glandular trichomes, specimen No. KRAM-P 243/A/2
1d. Two-celled (typical) base of peltate glandular trichome, specimen No. KRAM-P 243/A/2
2a. Exceptionally rare (anomalous?) four-celled base of peltate glandular trichome, specimen No. KRAM-P 244/B/34/I
2b. Peltate trichome shield, inside visible (arrow) remains of resinous secretion, specimen No. KRAM-P 244/B/34/I

Populus populina (Brongniart) Knobloch

3. Adaxial epidermis, specimen No. KRAM-P 244/B/6/II
4. Abaxial epidermis with stomata, specimen No. KRAM-P 244/B/15/I

Scale bar – 50 µm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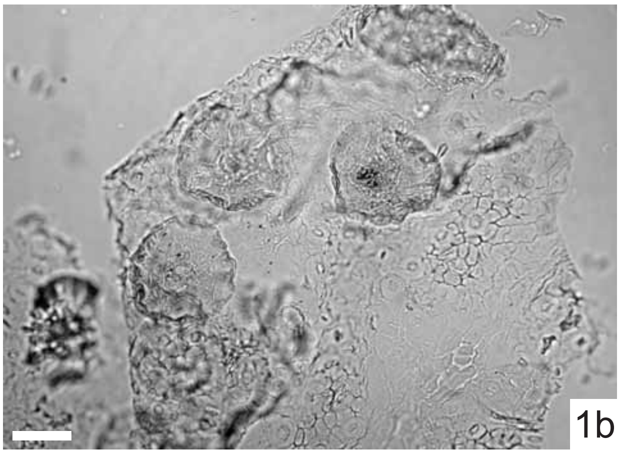
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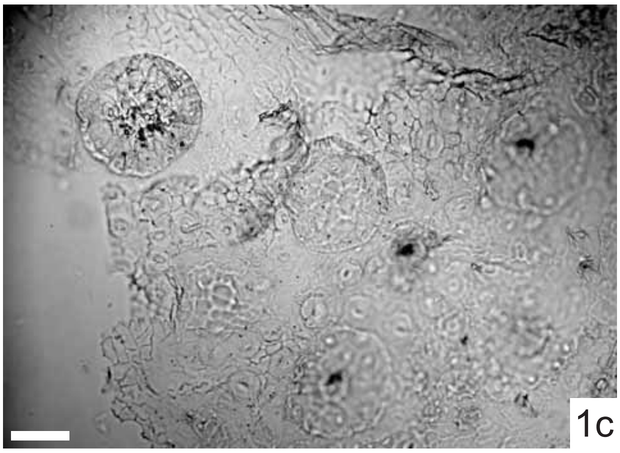
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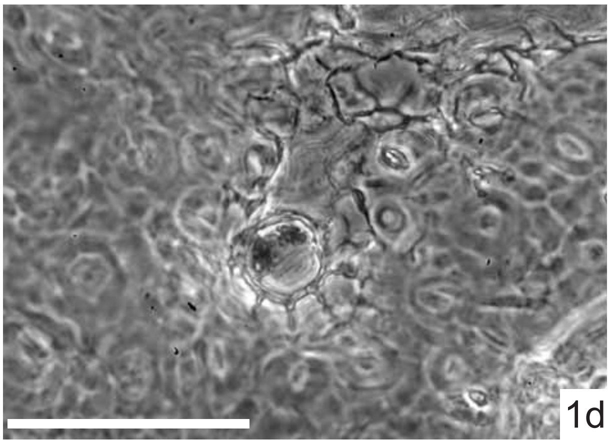
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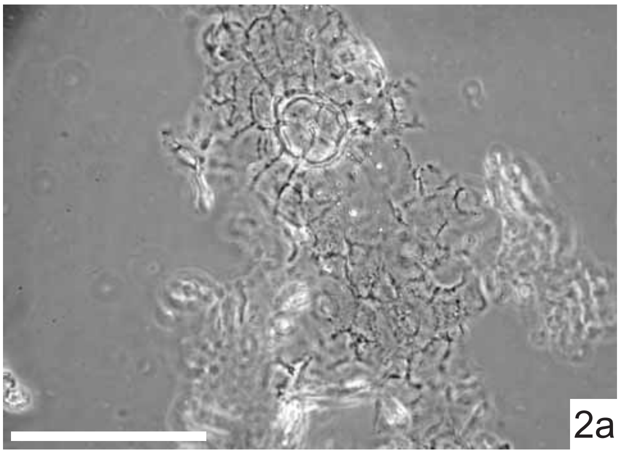
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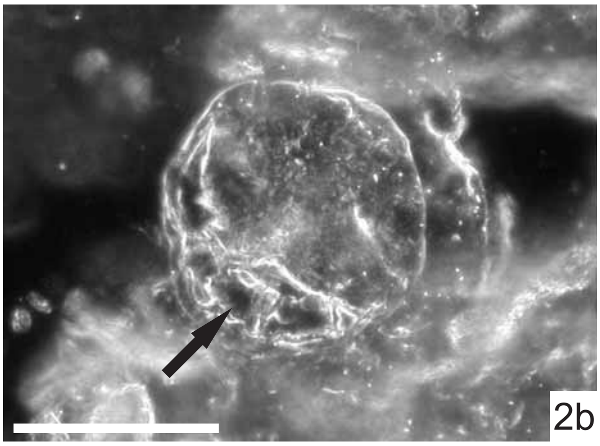
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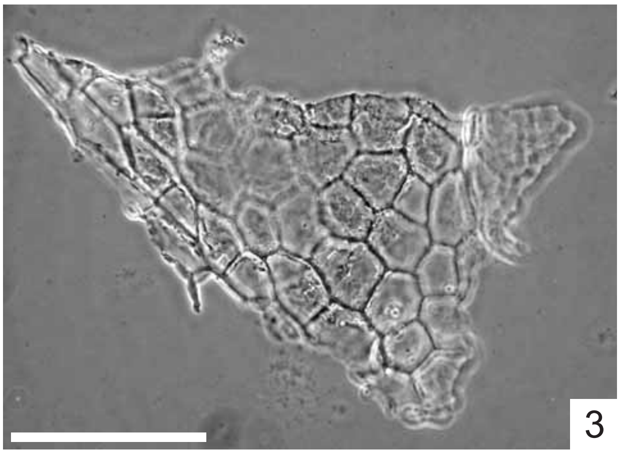
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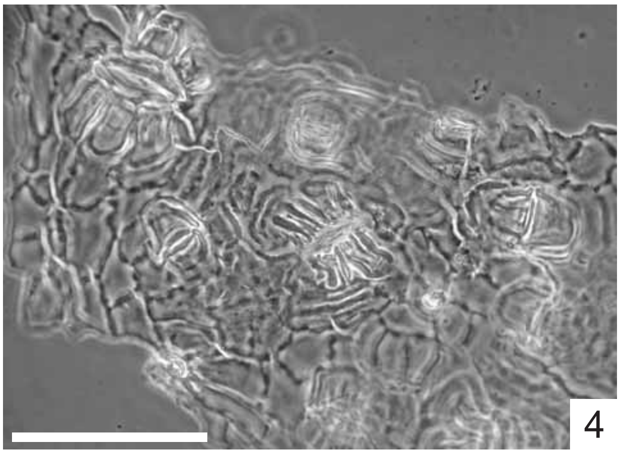
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Plate 13

Populus populina (Brongniart) Knobloch

1. Abaxial epidermis with stomata and unicellular trichome base, specimen No. KRAM-P 244/B/32

cf. *Populus* sp.

2. Abaxial epidermis with stomata, specimen No. KRAM-P 244/B/3
3. Abaxial epidermis with stomata, specimen No. KRAM-P 244/B/7

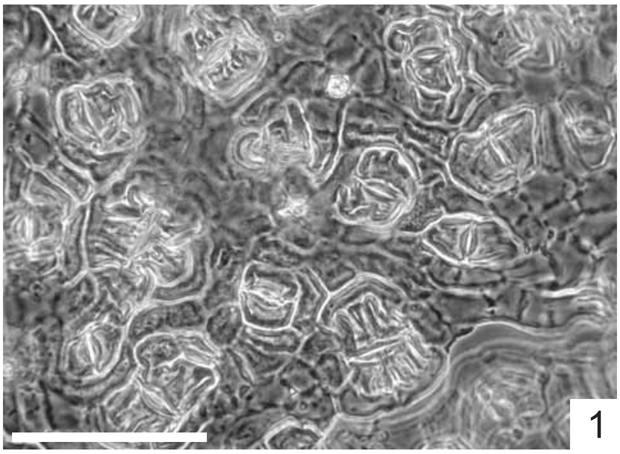
4a. Possibly adaxial epidermis with cuticular reticulate ornamentation, specimen No. KRAM-P 244/B/16

4b. Epidermis with preserved rosettes of crystalloids of epicuticular wax (arrows), specimen No. KRAM-P 244/B/16

Salix hausruckensis Kovar-Eder

5. Adaxial epidermis, specimen No. KRAM-P 243/B/3/I
6. Adaxial epidermis, specimen No. KRAM-P 244/B/36
7. Abaxial epidermis with stomata and isolated trichome bases, specimen No. KRAM-P 244/B/23

Scale bar – 50 µm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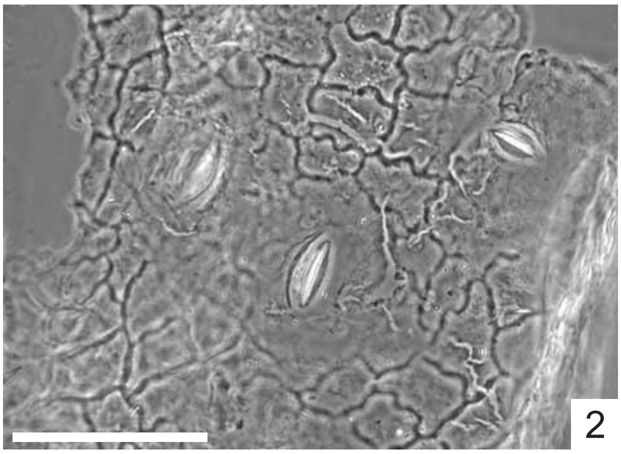
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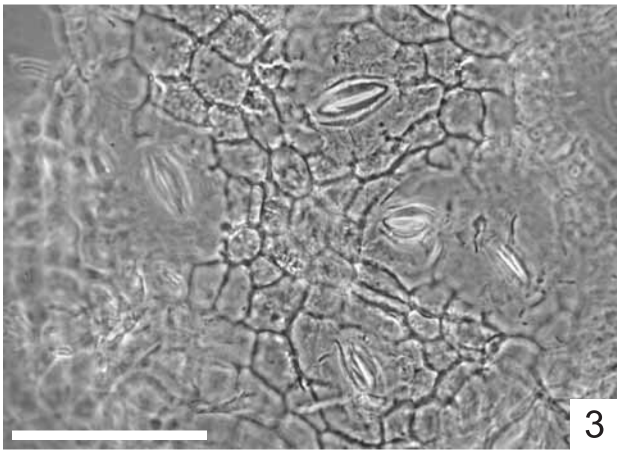
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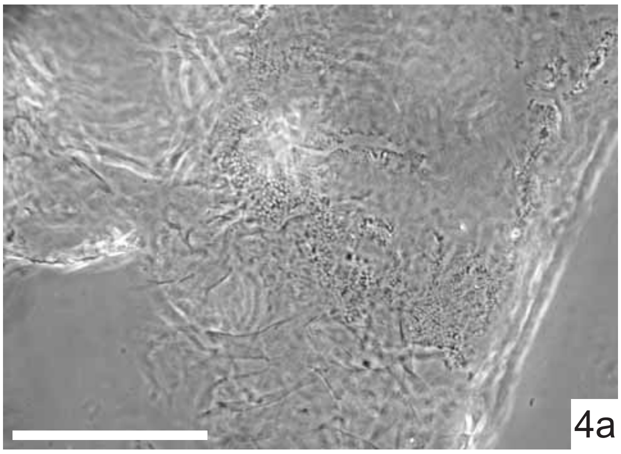
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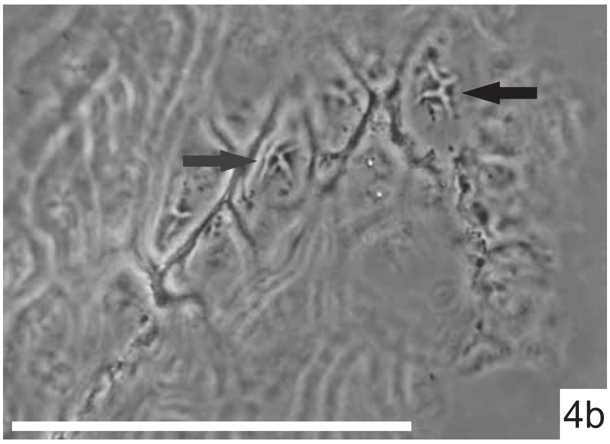
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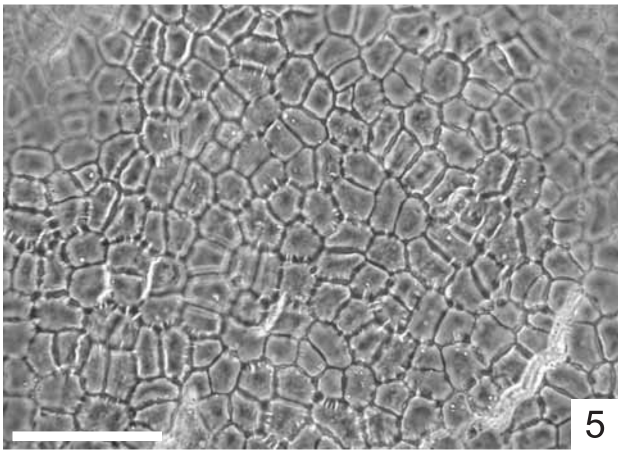
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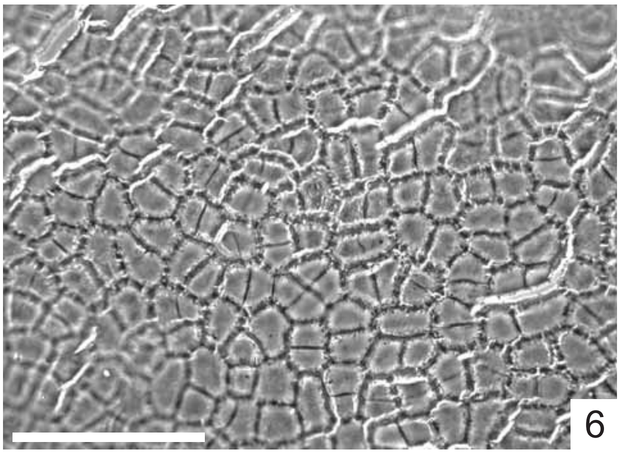
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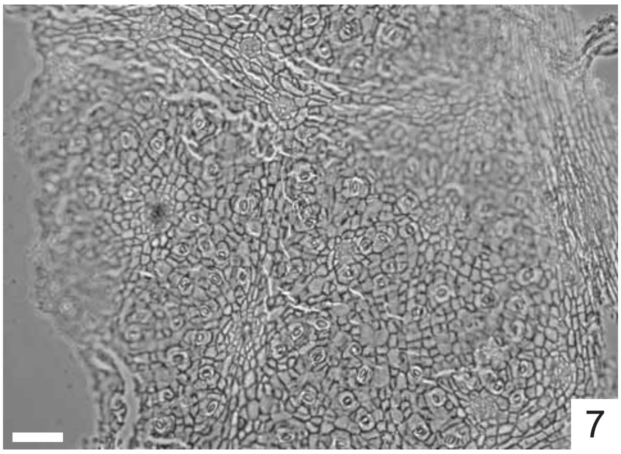
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Plate 14

Salix hausruckensis Kovar-Eder

1. Abaxial epidermis with different types of stomata: A – anomocytic, B - anisocytic C – brachyparacytic, specimen No. KRAM-P 244/B/36
2. Abaxial epidermis with stomata, preserved granules of epicuticular wax, specimen No. KRAM-P 243/B/3/I

Salix varians Goeppert *sensu lato*

3a. Adaxial epidermis, specimen No. KRAM-P 244/B/17/I

3b. Abaxial epidermis with stomata and unicellular trichome base, specimen No. KRAM-P 244/B/17/I

4. Adaxial epidermis with dense cuticular striations, specimen No. KRAM-P 243/A/24

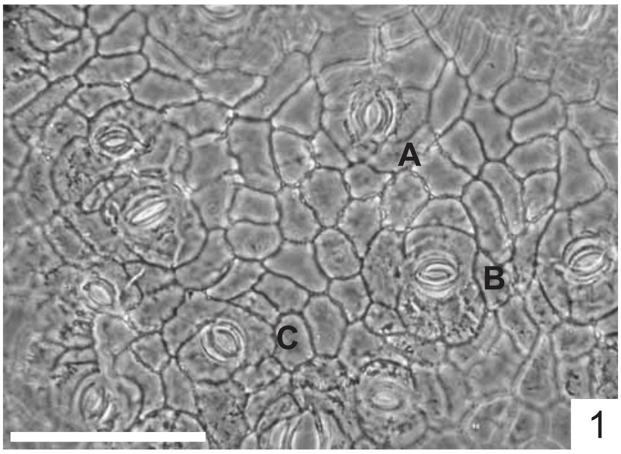
Salix sp. 1

5. Adaxial epidermis over the vein, specimen No. KRAM-P 243/A/5/II
6. Abaxial epidermis with stomata and trichome base, specimen No. KRAM-P 243/A/11/I

Pterocarya paradisiaca (Unger) Ilinskaya

7. Adaxial epidermis, specimen No. KRAM-P 243/D/2/III

Scale bar – 50 µm



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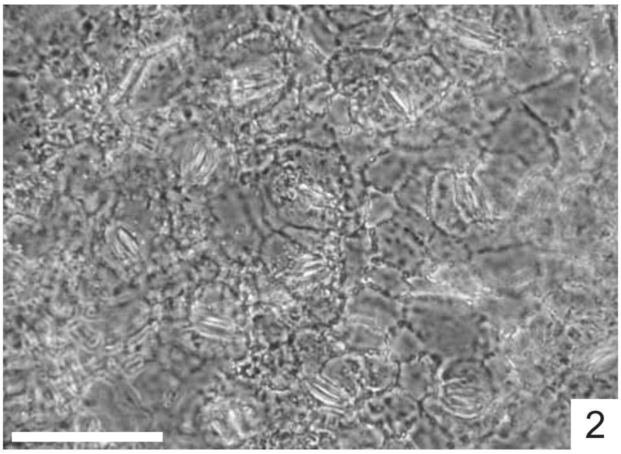
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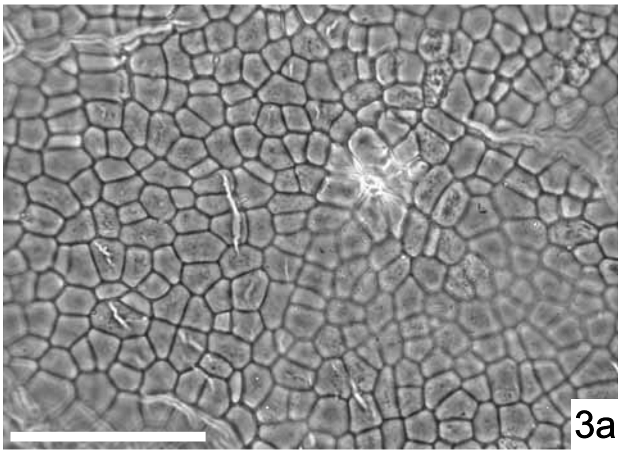
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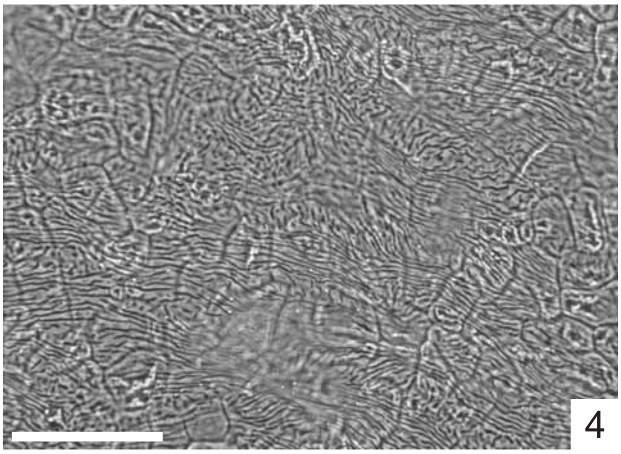
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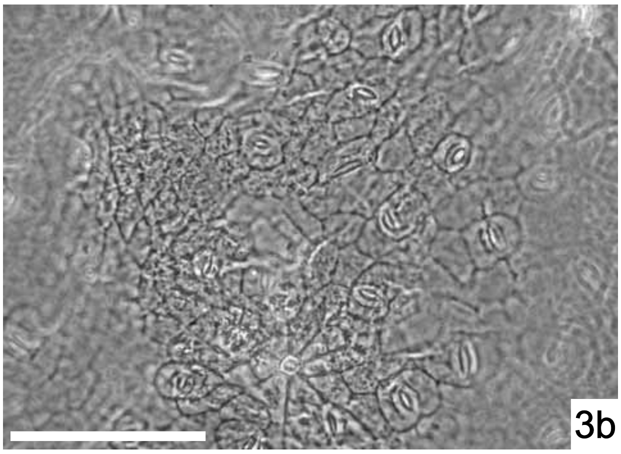
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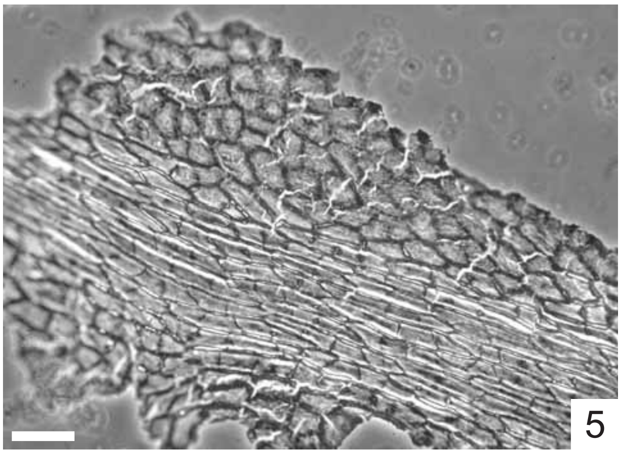
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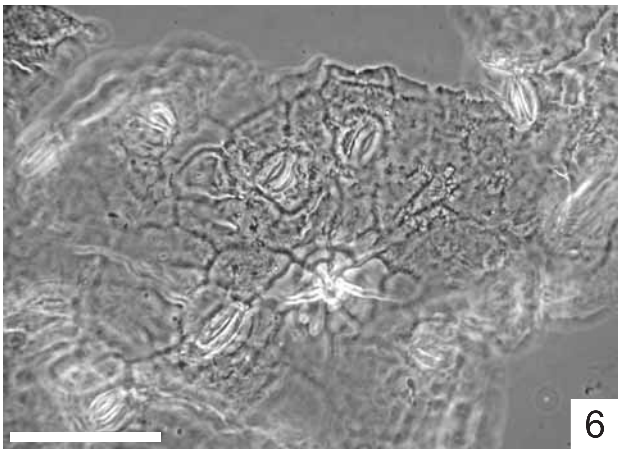
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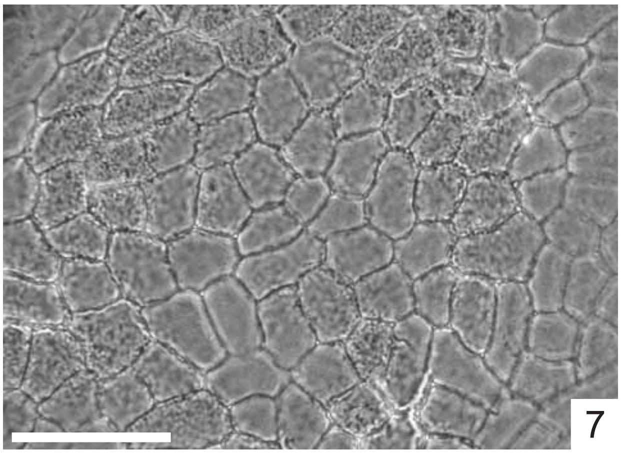
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Plate 15

Pterocarya paradisiaca (Unger) Ilinskaya

1a. Abaxial epidermis with stomata and unicellular trichome base, specimen No. KRAM-P 243/D/2/III
1b. Peltate glandular trichome with unicellular trichome base detached from abaxial epidermis, No. KRAM-P 243/D/2/III

„Castanea” kubinyii Kováts ex Ettingshausen *sensu* Knobloch & Z. Kvaček

2a. Adaxial epidermis, specimen No. KRAM-P 243/D/30/I
2b. Abaxial epidermis with stomata, specimen No. KRAM-P 243/D/30/I
2c. Abaxial epidermis with stomata, specimen No. KRAM-P 243/D/30/I

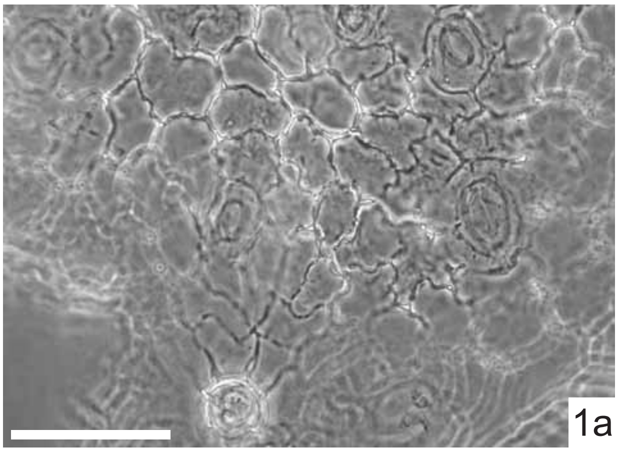
Ulmus cf. *ruszovensis* Hummel

3a. Abaxial epidermis with stomata, specimen No. KRAM-P 243/D/2/II
3b. Abaxial epidermis with stomata and poorly visible trichomes (arrows), specimen No. KRAM-P 243/D/2/II

Ulmus sp.

4. Abaxial epidermis with stomata, specimen No. KRAM-P 244/B/6/I

Scale bar – 50 µm



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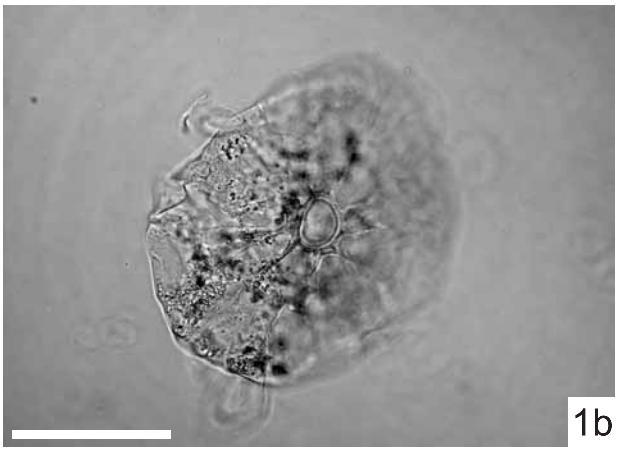

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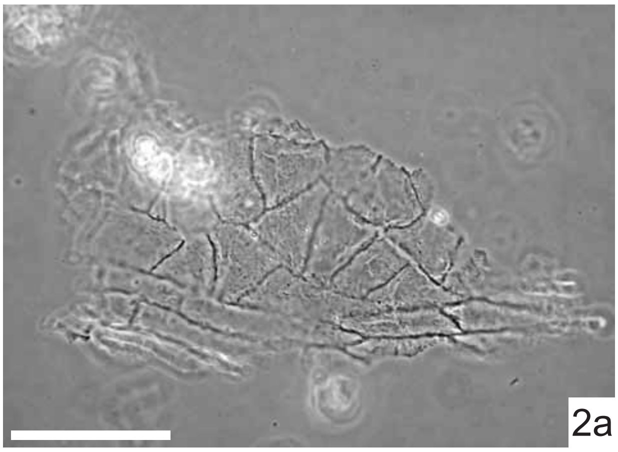

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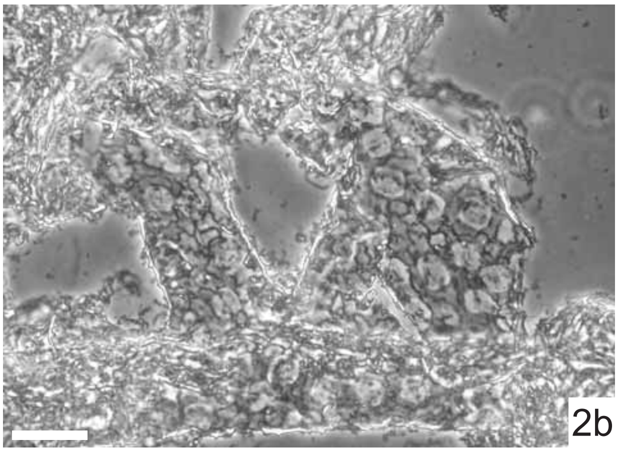

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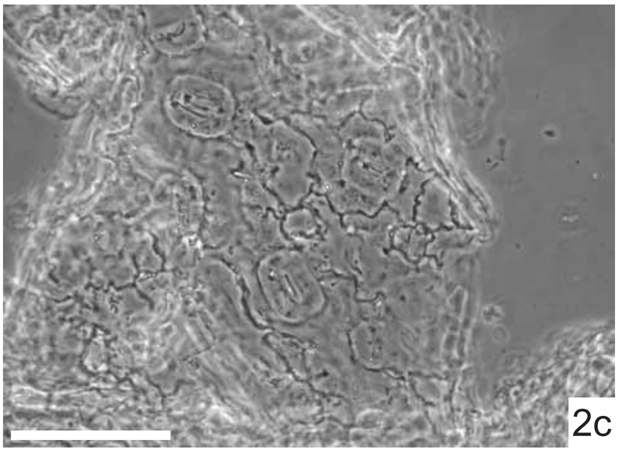

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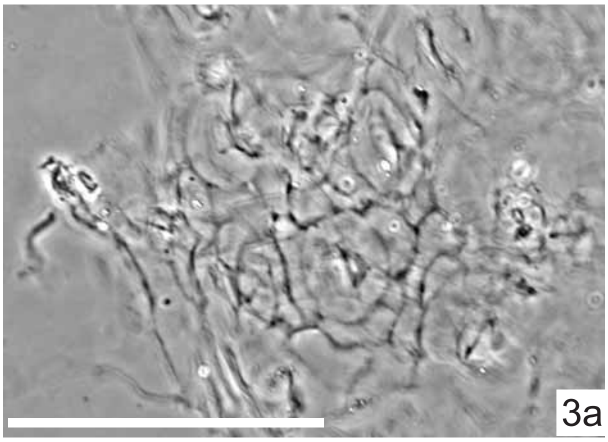

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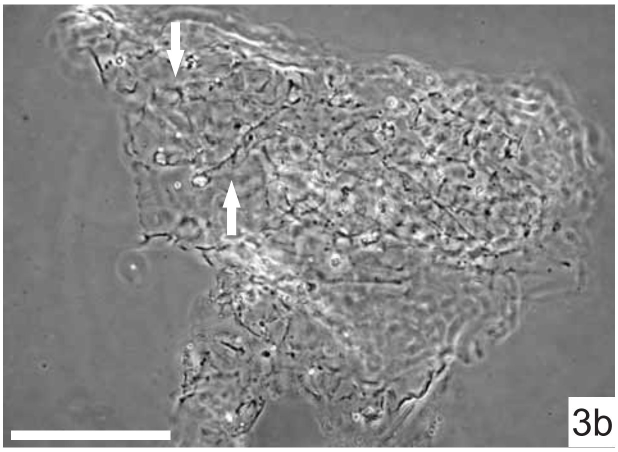

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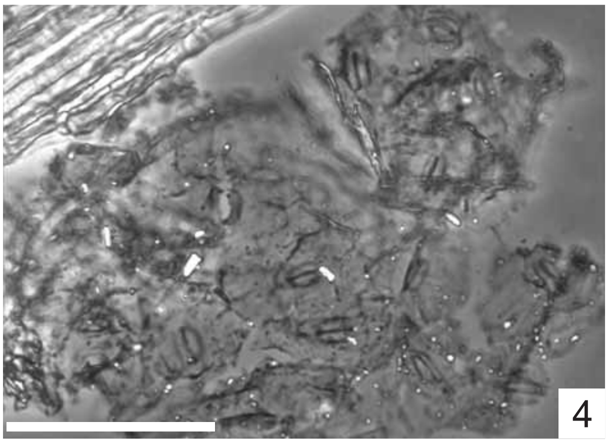


4

Plate 16

Ulmus sp.

1. Abaxial epidermis with stomata, specimen No. KRAM-P 244/C/14

Dicotylophyllum sp. 1

2a. Adaxial epidermis, specimen No. KRAM-P 243/C/2/I
2b. Abaxial epidermis with stomata, specimen No. KRAM-P 243/C/2/I
3. Abaxial epidermis with stomata, specimen No. KRAM-P 243/B/12

Dicotylophyllum sp. 2

4a. Adaxial epidermis, specimen No. KRAM-P 244/C/3/II
4b. Abaxial epidermis with stomata, specimen No. KRAM-P 244/C/3/II

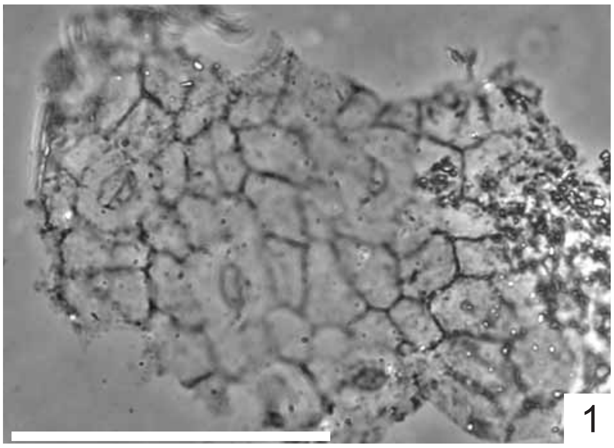
Dicotylophyllum sp. 3

5. Abaxial epidermis (?) with stomata, specimen No. KRAM-P 244/C/8/III

Phragmites oeningensis A. Braun

6. Epidermis, specimen No. KRAM-P 244/B/26/I

Scale bar – 50 µm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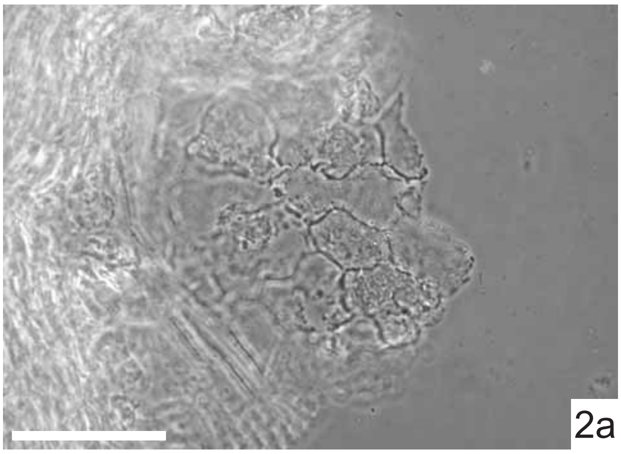
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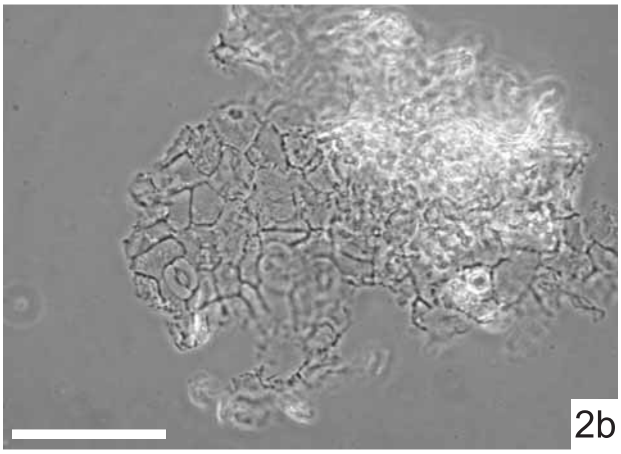
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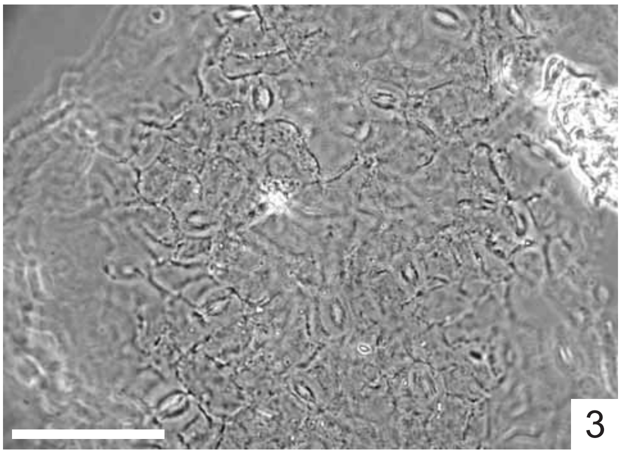
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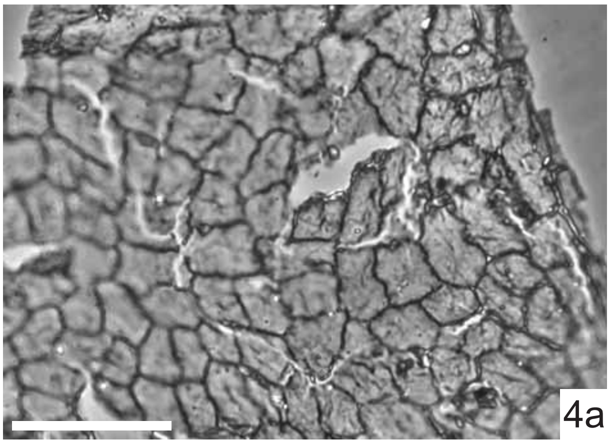
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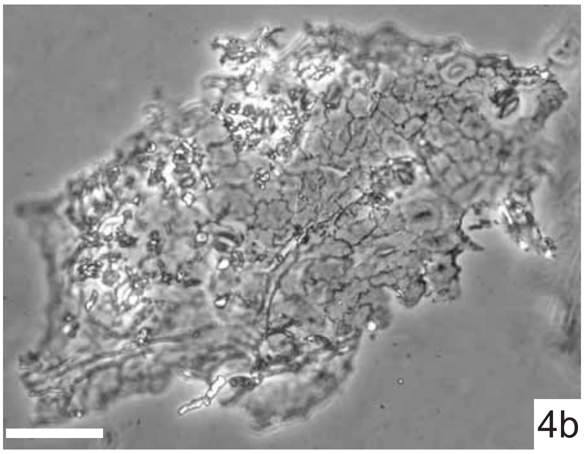
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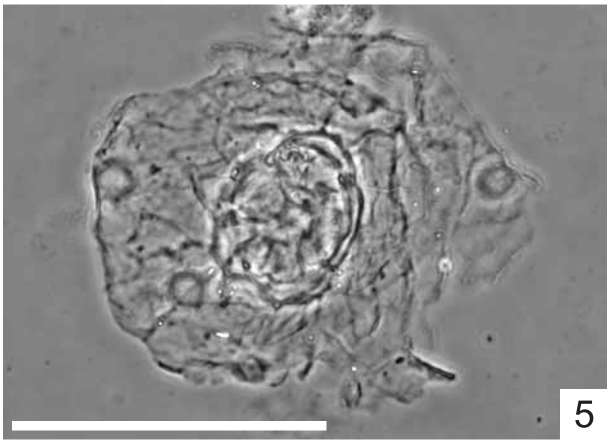
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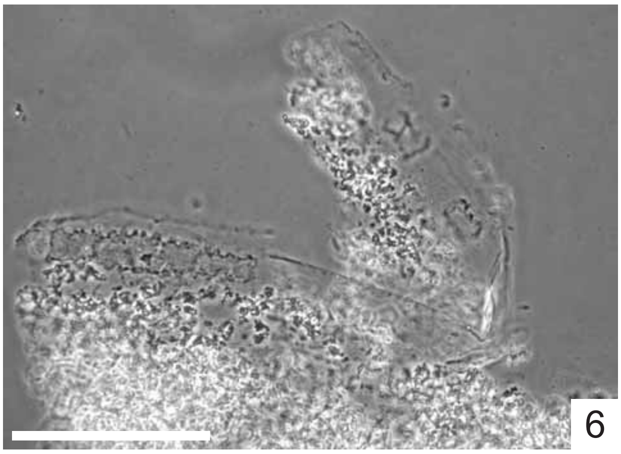

6

Plate 17

Cyperacites sp.

1. Epidermis, visible dense traces of probably silica bodies or papillae, specimen No. KRAM-P 243/B/3/II

Zingiberoideophyllum liblarense Kräusel & Weyland

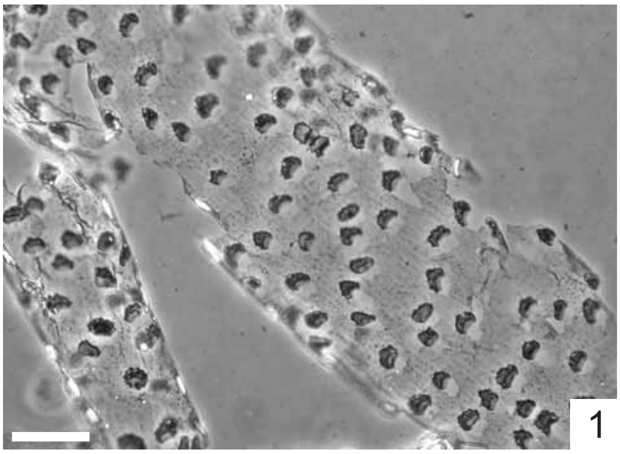
2. Detail of leaf venation, visible cross-veins and rests of content of secertory cells (dark) inside mesophyll, specimen No. KRAM-P 244/C/2/I

3a. Adaxial epidermis, specimen No. KRAM-P 244/C/21
3b. Adaxial epidermis, specimen No. KRAM-P 244/C/21
3c. Abaxial epidermis with stomata, specimen No. KRAM-P 244/C/21
3d. Abaxial epidermis with stomata, specimen No. KRAM-P 244/C/21

Hydrocharitaceae Jussieu gen. indet.

4a. Detail of leaf margin with hook-shaped prickles, specimen No. KRAM-P 244/C/24/II
4b. Single hook-shaped prickle, specimen No. KRAM-P 244/C/24/II

Scale bar – 50 µm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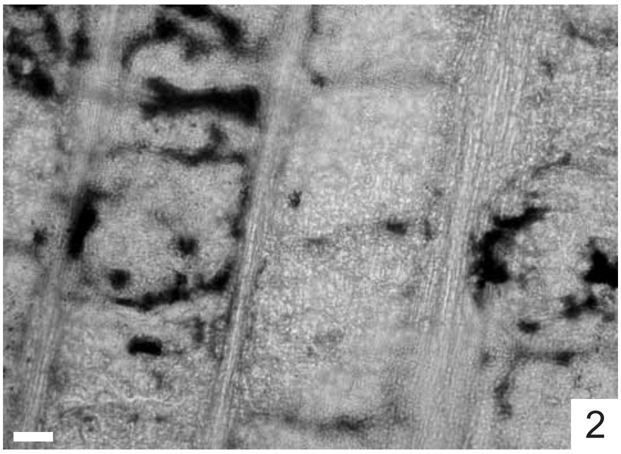
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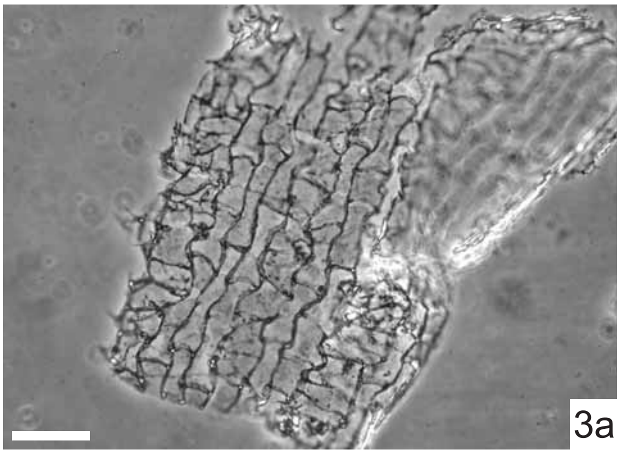
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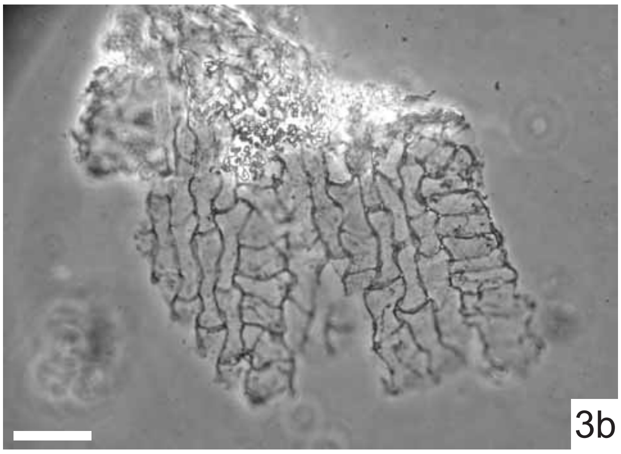
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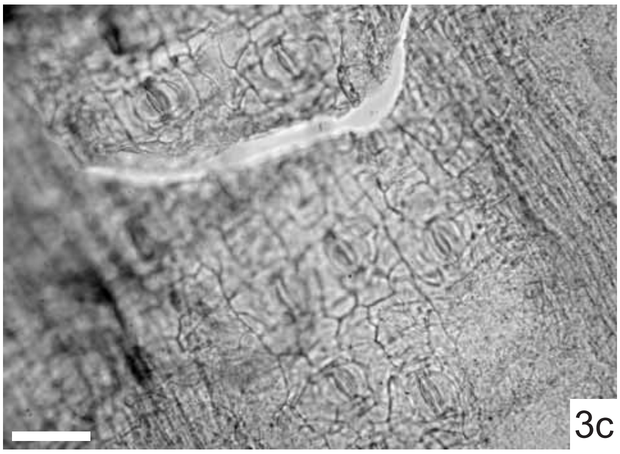
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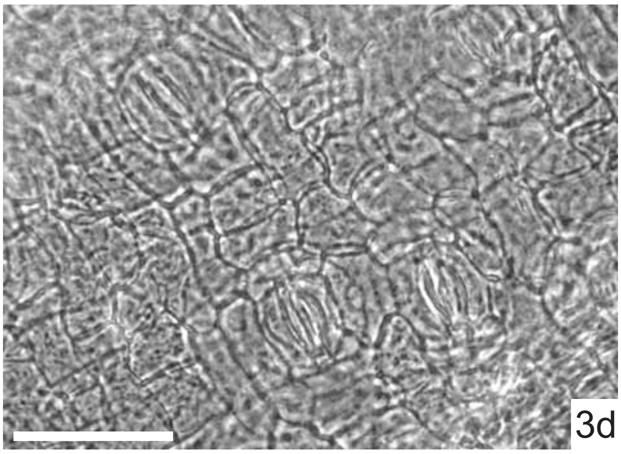
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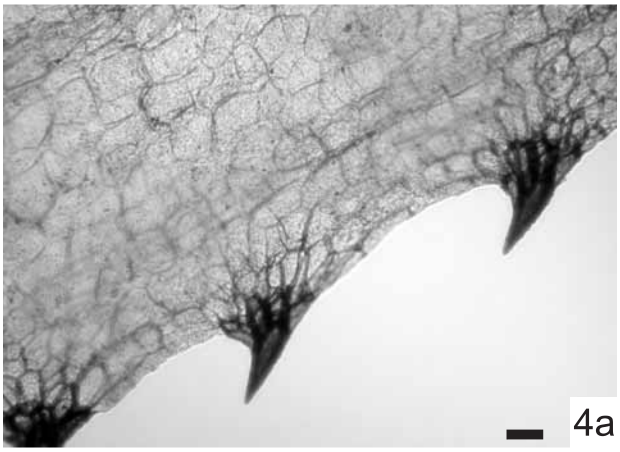
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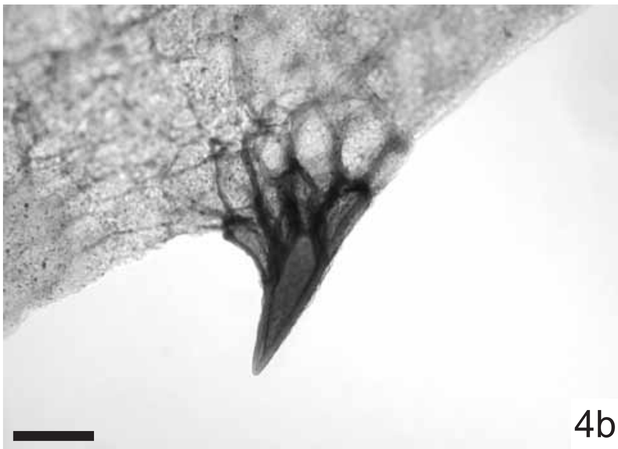

4b

Plate 18

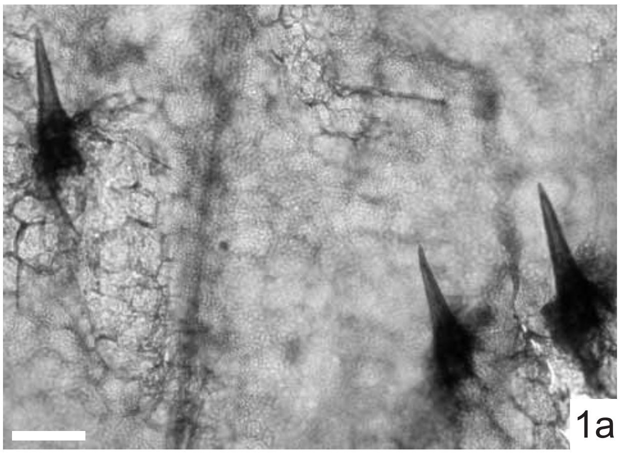
Hydrocharitaceae Jussieu gen. indet.

1a. Spine-shaped prickles on the leaf blade surface, specimen No. KRAM-P 244/C/19/I
1b. Epidermal cells, specimen No. KRAM-P 244/C/19/I
2. Epidermal and mesophyll cells, specimen No. KRAM-P 244/C/24/II
3a. Single hook-shaped prickle of another type, specimen No. KRAM-P 244/C/24/I
3b. Epidermal cells of another type, specimen No. KRAM-P 244/C/24/I

cf. *Varipilicutis liblarensis* (Kräusel & Weyland) Schneider

4a. Adaxial epidermis, specimen No. KRAM-P 244/C/2/II
4b. Abaxial epidermis with stomata, specimen No. KRAM-P 244/C/2/II
4c. Detail of stoma structure, specimen No. KRAM-P 244/C/2/II

Scale bar – 100 µm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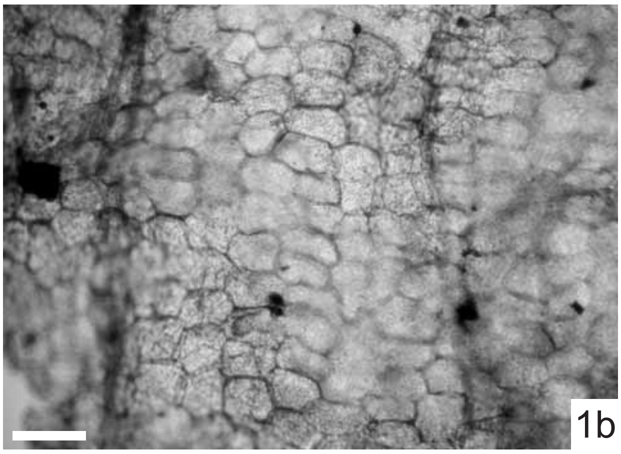
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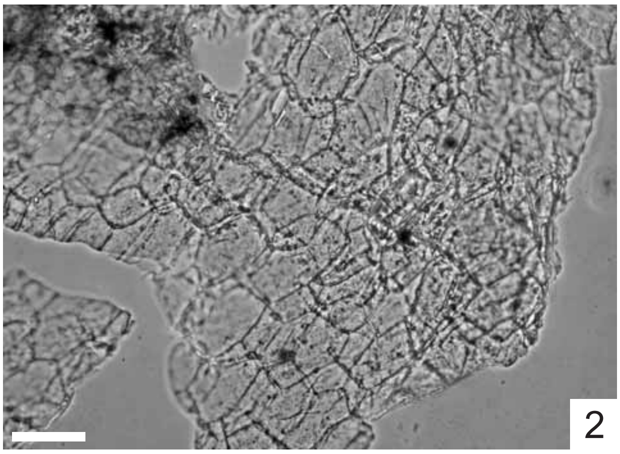
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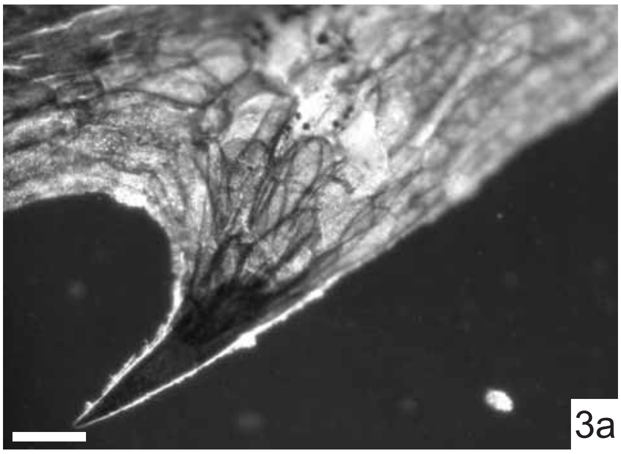
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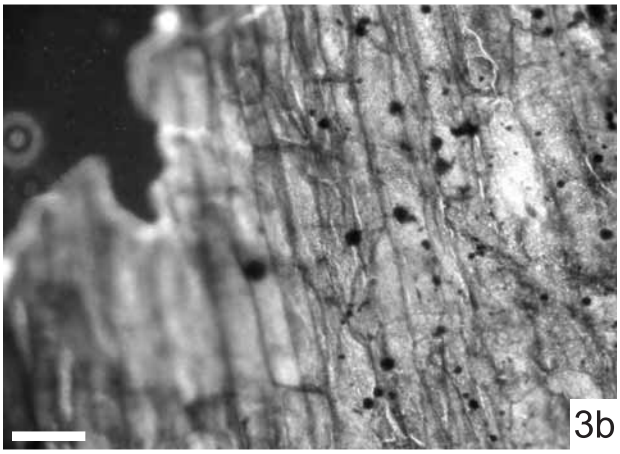
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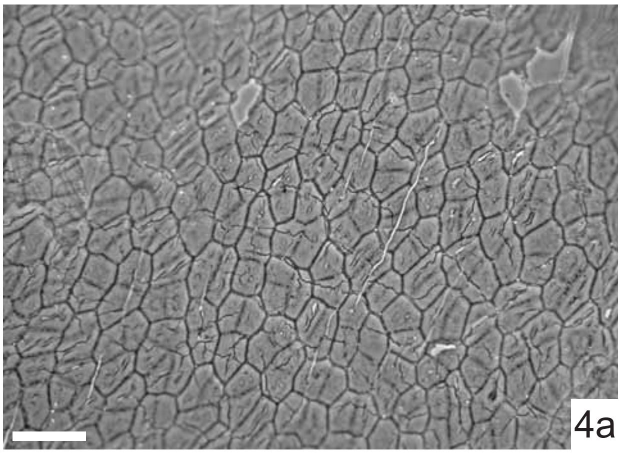
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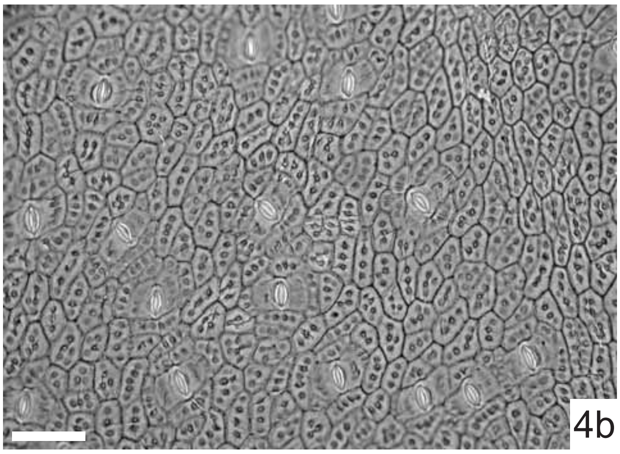
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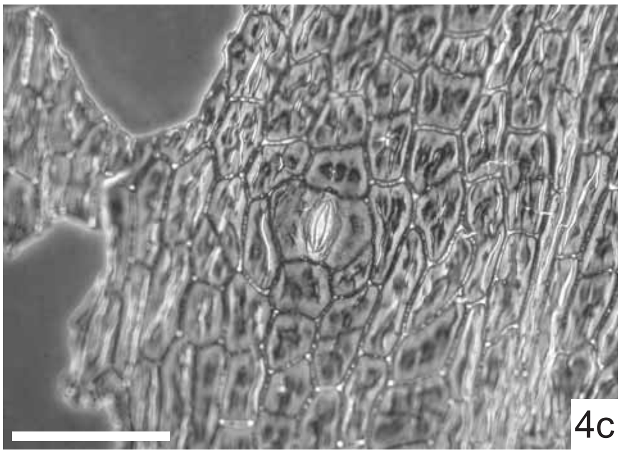
4c