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Dispersed cuticles from the Neogene Ruja lignite deposit near Legnica, Lower Silesia, Poland

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ABSTRACT. Dispersed cuticles from two boreholes, Komorniki 97/72 and 97/73, drilled in Ruja lignite deposit near Legnica, Lower Silesia, Poland were investigated. Altogether 19 taxa from 13 genera were identified, belonging to 11 families of pteridophyta, gymnosperms and angiosperms. Two new taxa were described (*Salix semihausruckensis* sp. nov. and *Dicotylophyllum rujense* sp. nov.). As with the leaf macroremains from the same samples, all dispersed cuticle assemblages are characterized by dominance of floristic elements of the wetland vegetation. The floristic composition confirms their Middle Miocene (Badenian) age, and the existence of warm temperate climate conditions with mild winters.

KEY WORDS: Dispersed cuticles, wetland vegetation, Ruja lignite deposit, Middle Miocene, Lower Silesia, Poland

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INTRODUCTION

As well as macroremains of leaves, continental Cenozoic deposits sometimes also contain dispersed, very small, fragments of leaf blades and, especially in lignites, isolated (naturally macerated) leaf cuticles. These fossils are named dispersed cuticles (Latin *cuticulae dispersae*), and have been investigated since the beginning of twentieth century (see Upchurch 1995). They have been the basis of numerous publications (e.g. Jähnichen 1965, Litke 1966, Roselt & Schneider 1969, Schneider 1969a, 1969b, 1977, 1980, 1992, 1998, 2004, Juchniewicz 1975a, 1978, Kovach & Dilcher 1984, Rowett & Sparrow 1994, Upchurch 1995, Pole 2007a, 2007b). Research into *cuticulae dispersae* has considerably expanded our knowledge of Cenozoic vegetation and, especially in case of European Neogene, of the geology of lignite formation (e.g. Schneider 1969b, 1992, Juchniewicz 1975b). Until now the only investigations of dispersed cuticles from Cenozoic of Poland had been carried out by Juchniewicz (1966, 1970, 1973, 1975a, b, 1978) on the material from Lower Miocene deposits from Turów Lignite Mine. The research described in this paper is on the palaeofloristics and palaeoecology of dispersed cuticles isolated from selected horizons with fossil leaf litters. They are from

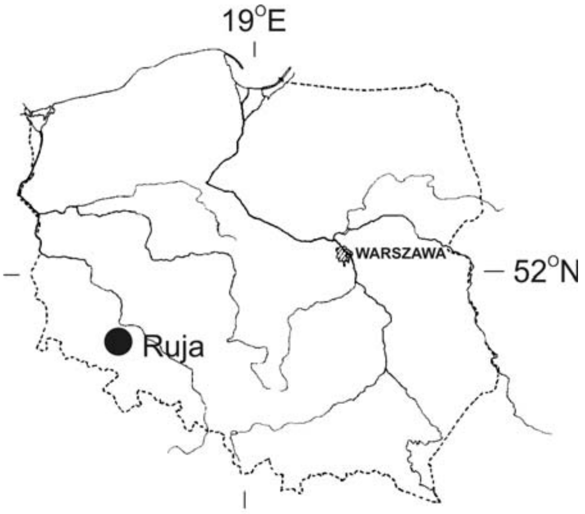

Fig. 1. Location of the Ruja lignite deposit in Poland

boreholes Komorniki 97/72 and 97/73, drilled in 1991 at the Ruja lignite deposit. Besides dispersed cuticles, abundant accumulations of plant macroremains were found. These macroremains, mainly fossil leaves, have already been investigated (Worobiec et al. 2008).

The first author (Grzegorz Worobiec) has investigated the dispersed cuticles and edited the manuscript, while Jacek Kasiński described geological properties of the Ruja lignite deposit.

GEOLOGY

The Ruja deposit belongs to the Legnica-Ścinawa lignite resource complex, west of Wrocław, Lower Silesia, the largest lignite-bearing area in Poland. It is located in the southernmost part of this complex (Fig. 1). The geology of the area was described in Worobiec et al. (2008).

The samples were collected from two borehole cores, Komorniki 97/72 and Komorniki 97/73. Core fragments with fossil material come from Middle Miocene (Badenian) deposits belonging to the Pawłowice Formation and the lowermost part of Poznań Formation (Worobiec et al. 2008). The position of the core samples is shown in Figure 2.

The sediments with macroremains and dispersed cuticles were deposited within periodical lakes and oxbows (Worobiec et al. 2008).

MATERIAL AND METHODS

The samples were taken from accumulations of compressed fossil leaf litters, collected in 1996 in the course of palynological sampling of the cores from boreholes Komorniki 97/72 and Komorniki 97/73 (Worobiec et al. 2008).

From borehole core 97/72 material of leaf litter comes from depths 78–79 m (KRAM-P 243/A/CDisp), 105–106 m (KRAM-P 243/B/CDisp), and 117 m (KRAM-P 243/E/CDisp) and from core 97/73 from depths 102–105 m (KRAM-P 244/B/CDisp), and 107–110 m (KRAM-P 244/C/CDisp).

To isolate dispersed cuticle remains from fossil leaf litter, samples were bulk macerated by immersion in 40% hydrofluoric acid in a closed plastic container under fume hood for 1–2 weeks. Then the spent HF acid was poured off, and the macerated litter was rinsed in water several times until it was neutralized. Macerated material was carefully checked under binocular to select fragments of humified leaf blades for isolation of cuticles. Fragments of leaves were macerated for up to 3–4 hours (dependent on leaf taxa) using a diluted solution of commercial bleach "Bielnar" (solution of NaClO, comp. Dilcher 1974). The isolated cuticular fragments were then mounted in glycerine jelly microscope slides for light microscopy. Some of the naturally macerated cuticles and other plant remains were directly mounted without maceration. Altogether 526 slides of dispersed cuticles were prepared.

The slides of dispersed cuticles are housed at the Władysław Szafer Institute of Botany Polish Academy of Sciences, Kraków. Microscopical slides with mounted material are prefixed with KRAM-P and the horizon number, and are also labelled as of dispersed cuticle origin ("CDisp").

The nomenclature of the dispersed cuticles is based on Linnean hierarchy, using taxonomic names of previously known macroremains of fossil leaf taxa with the same micromorphology of cuticles, or the names of earlier described *cuticulae dispersae*. In case of indeterminate cuticular remains of dicotyledons, the genus name *Dicotylophyllum* is used.

The nomenclature of recent genera, families or higher taxa is based on APG II (2003).

Bright field, dark field and phase contrast microphotography of the fossil leaf epidermis were made using NIKON Eclipse E400 microscope fitted with the CANON A640 digital camera.

Features of micromorphological structures 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 wide elliptical stomata had their longest dimension measured (size).

Because the localities of fossil floras in territory of Poland changed their names after Second World War, below are the new and old names, after Łańcucka-Środoniowa el al. (1983). Old names present in papers published before 1945 year are given in brackets: Chroślice (Hennersdorf), Kokoszyce (Kokoschütz),

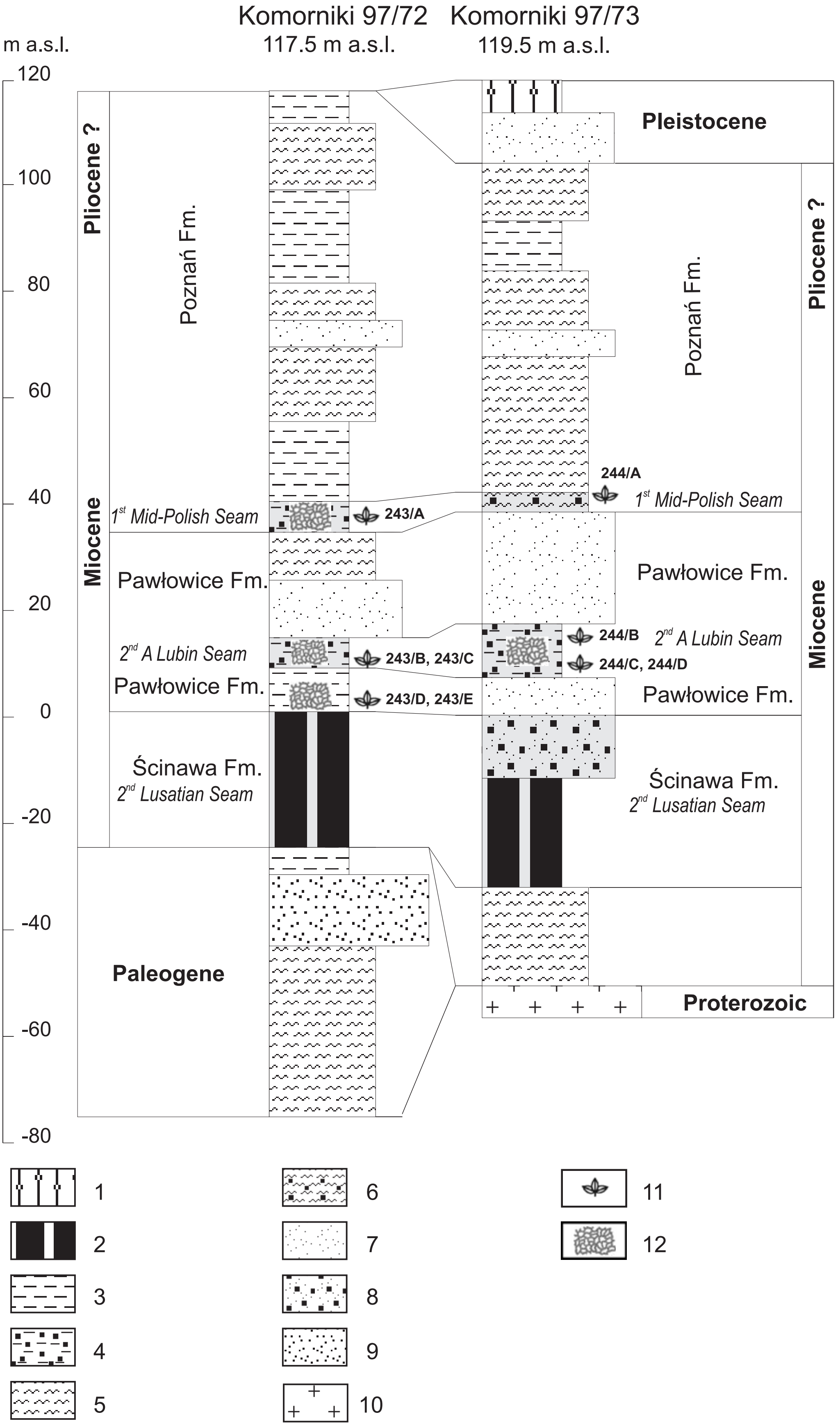

Fig. 2. Geological profiles of boreholes Komorniki 97/72 and Komorniki 97/73 with position of horizons with plant macroremains and palynological samples (after Worobiec et al. 2008, slightly changed): **1**– till, **2** – lignite, **3** – clay, **4** – clay and lignite, **5** – silt, **6** – silt and lignite, **7** – sand, **8** – sand and lignite, **9** – gravel stone, **10** – phyllite, **11** – horizons with plant macroremains, **12** – horizons with dispersed cuticles

Koronowo (Crone a. Br.), Kunice Żarskie (Kunzendorf), Malczyce (Maltsch), Pietrusza (Peruschen), Pogalewo Wielkie (Gross Pogul), Rataje (Rataj bei Posen), Smogorzówek (Klein Schmograu), Stróża (Striese W.), Trzebnica (Trebnitz), Wichów (Niederweichau), Wołów (Wohlau), Zielona Góra (Grünberg).

SYSTEMATIC PART

Osmundaceae Berchtold & J.S. Presl

Osmunda **L.**

Osmunda parschlugiana (Unger) Andreánszky

Pl. 1, figs 1–3

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

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

2008 *Osmunda parschlugiana* (Unger) Andreánszky; Worobiec et al., p. 197, Fig. 3: 1, 2; pl. 1, fig. 1, pl. 8, figs 1, 2.

Material. KRAM-P 243/A/CDisp/: 13–35; KRAM-P 243/E/CDisp/: 192–195.

Macromorphology. Small fragments of pinnae of fern fronds with serrate margin, teeth very small. Lateral veins arranged at intervals of 0.50–0.65 mm. Veins terminate in the sinuses between teeth. Vascular bundle of vein branched upward, branch rapidly becoming thinner and thinner.

Micromorphology. Adaxial epidermis (usually rather badly preserved) composed of irregular-shaped cells with undulate and thin anticlinal cell walls, ca. 22–40 μm in size. Cuticle granular. Abaxial epidermis composed of irregular-shaped cells, 75–175 μm in size with usually Ω–undulate and thick (but sometimes thin) anticlinal cell walls. Cells with trichomes smaller, usually not elongated (60–82 μm in size) having less undulate walls. Leaves hypostomatic. Stomata anomocytic, elliptic to wide elliptic, 40–65 μm long and 35–47 μm wide. Outer stomatal ledge aperture wide elliptic, 25–45 μm long and 12.5–32.5 μm wide, surrounded by cuticular "crest". Indistinct T-shaped polar cuticular thickenings visible. On the both epidermal layers unicellular, simple (unbranched) trichomes were found, numerous in places, 70–212 μm long with acute apical ends. Trichome bases elliptic-rounded, unicellular, 17.5–30.0 μm in diameter.

Remarks. These leaflet/cuticular fragments have been assigned to *Osmunda parschlugiana* (Unger) Andreánszky on the basis of macro and micromorphology. The dispersed cuticle described as "*Pteris*" *parschlugiana* Unger by Kräusel and Weyland (1954) differs in respect of shape of epidermal cells. *Osmunda parschlugiana* is considered to have been a component of swampy vegetation in the Neogene flora of central Europe (Mai 1995).

Occurrence in the fossil floras of Poland. Early Miocene – Bełchatów (Worobiec 1995, 2003); Middle Miocene – Ruja (Worobiec et al. 2008); Miocene – Chroślice (Kräusel 1920, as *Pteris parschlugiana* Unger).

Cupressaceae Rich. ex Bartling

Glyptostrobus **Endl.**

Glyptostrobus europaeus (Brongniart) Unger

Pl. 2, figs 1–3

1833 *Taxodium europaeum* Brongniart, p. 168, pl. 3, pl. 12.

1850b *Glyptostrobus europaeus* (Brongniart) Unger, p. 434–435.

2008 *Glyptostrobus europaeus* (Brongniart) Unger; Worobiec et al., p. 198, pl. 1, figs 3, 7, 8, pl. 8, figs 3–5.

Material. KRAM-P 243/A/CDisp/: 186, 187; KRAM-P 243/B/CDisp/: 14; KRAM-P 243/E/CDisp/: 158-180, 185, 238-240; KRAM-P 244/C/CDisp/: 6.

Micromorphology. Epidermal cells quadrangular, mostly elongate, 17.5–52.5 μm long and 12.5–25.0 μm wide. Anticlinal cell walls thick, straight. Cuticle rather thick, distinctly granulate. The hypodermal cells quadrangular, frequently square, up to 55 μm long, cell walls distinctly thinner than epidermal. Stomata cyclocytic, elliptic, sometimes deformed, 42.0–62.5 μm long and 25.0–37.5 μm wide. Stomata arranged in stomatal bands of variable length. Outer stomatal ledge aperture distinctly cutinized, elongated, oblongate, 12.5–23.0 μm long and 2,5–5.0 μm wide. Polar T-shaped cuticular thickness present, very distinct.

Remarks. The micromorphology of cuticles corresponds to the fossil species *Glyptostrobus europaeus* (Brongniart) Unger. Cuticle of common Neogene fossil species *Sequoia abietina* (Brongniart) Knobloch differs in having considerably longer epidermal cells. Morphologically similar *Quasisequoia couttsiae* (Heer) Kunzmann differs from *Glyptostrobus europaeus* in the epidermal structure (comp. Kunzmann 1999). *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 modern counterpart of *Glyptostrobus europaeus*, growing on river banks, often in swampy places in a small areas in southern China and Vietnam (Henry & McIntyre 1926, Hiêp & Vidal 1996).

Occurrence in the fossil floras of Poland. *Glyptostrobus europaeus* is a common component of Neogene floras from Poland (Worobiec et al. 2008).

Dicotyledones

Sapindaceae Jussieu

Acer L.

Acer sp.

Pl. 2, figs 4, 5

Material. KRAM-P 243/E/CDisp/: 111, 181, 187, 197.

Micromorphology. Adaxial epidermis composed of considerably large, isodiametric cells, with mostly straight, thick walls, 25–50 μm in size. Cuticle with distinct, parallel striae ornamentation. Abaxial epidermis composed of more or less isodiametric cells with rounded, sometimes slightly undulate cell walls, 15–25 μm in size. Surface of cuticle sometimes granular (probably due to presence of epicuticular wax). Leaves hypostomatic. Stomata elliptic, 17.5–20.0 μm in size. Outer stomatal ledge rather distinct, elliptic-rectangular, up to 20 μm long. On the abaxial epidermis are found unicellular, simple trichomes, up to 75 μm long with unicellular trichome base, 10–12.5 μm in diameter.

Remarks. Cuticular fragments assigned to genus *Acer* especially on the basis of the stomata features (typical elliptic-rectangular shape of outer stomatal ledge) and also the presence of unicellular, simple trichomes on the abaxial epidermis. It is not excluded that they could represent fossil maple *Acer tricuspidatum* Bronn sensu Procházka & Bůžek (Procházka & Bůžek 1975).

Betulaceae Gray

Alnus Miller

Alnus julianiformis (Sternberg) Z. Kvaček & Holý

Pl. 2, fig. 6, Pl. 3, figs 1–6

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, Fig. 6: 1–4, pl. 7, figs 2–5, 7, 9, 10, pl. 8, figs 1–4, 8, 10.

2008 *Alnus julianiformis* (Sternberg) Z. Kvaček & Holý; Worobiec et al., p. 202, pl. 9, fig. 5, pl. 10, fig. 1.

Material. KRAM-P 243/B/CDisp/: 15; KRAM-P 243/E/CDisp/: 65–67, 70, 71, 73, 75–81, 83–87, 90–93, 95–100, 102, 104, 105, 107, 110, 120, 128, 130, 143, 182/1, 184/I, 188/I.

Micromorphology. Adaxial epidermis cells isodiametric or slightly elongated, 11–25 μm in size with straight or rounded cell walls. Over the veins cells are strongly elongated and more or less rectangular. Cuticle covered by epicuticular wax. Abaxial epidermis composed of isodiametric or slightly elongated cells, 17.5–47.5 μm in size, over the veins cells are strongly elongated. Cell walls usually undulate, rarely rounded. Leaves mainly hypostomatic, exceptionally amphistomatic. Stomata anomocytic, raised over epidermis (through stomata are visible radial walls of cells lying under stoma), wide elliptic, elliptic, sometimes rounded, 20.0–32.5 μm in diameter. T-piece sometimes visible, indistinct. Outer stomatal ledge aperture spindle-shaped, 10.0–17.5 μm long and 4.0–7.5 μm wide. On the abaxial epidermis and sometimes on adaxial epidermis are found multicellular (almost always 4-celled, exceptionally 3 or 5 celled), rounded or wide elliptic trichome bases, 16.0–27.5 μm in diameter. Preserved peltate glandular trichomes measured 50–55 μm in diameter.

Remarks. Structure of stomatal complex (raised stomata) and undulate cell walls of abaxial epidermis are typical for *Alnus julianiformis* (Sternberg) Z. Kvaček & Holý. Micromorphological features of these remains matches accurately with cuticular data in leaf remains of *Alnus julianiformis* described earlier from the same locality (Worobiec et al. 2008). *Alnus julianiformis* was a common species in European Neogene floras (see Hummel 1991), and probably was a component of riparian and swamp forests.

Occurrence in the fossil floras of Poland. Early Miocene – Bełchatów (Worobiec 1995, 2003); Middle Miocene – Młyny (Zastawniak 1980), Ruja (Worobiec et al. 2008); Late Miocene – Sośnica (Knobloch 1971, Zastawniak & Walther 1998); Early Pliocene – Ruszów (Hummel 1991).

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

Material. KRAM-P 243/E/CDisp/: 69, 72, 74/I, 82, 88, 89, 94, 101, 103, 106, 195/I, 204.

Remarks. Cuticles of similar micromorphology to *Alnus julianiformis* but too poorly preserved for unambiguous identification.

Alnus menzelii Raniecka-Bobrowska

Pl. 3, fig. 7, Pl. 4, fig. 1

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

2008 *Alnus menzelii* Raniecka-Bobrowska; Worobiec et al., p. 203, Fig. 3: 10; pl. 2, fig. 8, pl. 3, fig. 1, pl. 7, fig. 1, pl. 10, figs 2–4.

Material. KRAM-P 243/B/CDisp/: 13.

Micromorphology. Adaxial epidermis composed of isodiametric to elongate, cells, 12.5–25.0 (35.0) μm in size. Over the veins cells are strongly elongated and rather narrow. Anticlinal cell walls usually straight. Cuticle of adaxial epidermis usually (but not always) distinctly striated and covered by epicuticular wax. Cells of abaxial epidermis isodiametric, over the veins cells strongly elongated, anticlinal cell walls rounded or characteristically undulate, 12.5–32.5 μm in size. Leaves hypostomatic. Stomata anomocytic, elliptic to rounded, 17.5–22.0 μm in diameter. Outer stomatal ledge aperture spindle-shaped, 9.0–12.5 μm long and 5.0–7.5 μm wide. On the abaxial epidermis, multicellular (mostly 4-celled) trichome bases, 20–30 μm in diameter were found.

Remarks. Micromorphological features of these dispersed cuticles, especially distinctly striated cuticle of adaxial epidermis and usually 4-celled trichome bases on the abaxial epidermis are both typical for fossil alder *Alnus menzelii* Raniecka-Bobrowska. *Alnus julianiformis* (Sternberg) Z. Kvaček & Holý differs in adaxial epidermis without striae, usually larger stomata, and variable-sized glandular trichome bases.

Alnus menzelii was a component of riparian and swampy forests (Zastawniak & Walther 1998).

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), Ruja (Worobiec et al. 2008); 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).

Malvaceae Juss.

Byttneriophyllum Givulescu ex Knobloch & Z. Kvaček

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

Pl. 4, figs 2–5, Pl. 5, figs 1–3

1845 *Cordia tiliaefolia* Al. Braun, p. 170.

1856 *Ficus tiliaefolia* A. Br., Heer, p. 68, 108, pl. 43, figs 3(?), 6–8, 9(?), 10, 11, 12(?), pl. 44, fig. 1–5.

1919 *Büttneria aequalifolia* (Goeppert) Meyer, p. 174, pl. 17, figs 2–4, pl. 26, fig. 12.

1965 *Byttneriophyllum tiliaefolium* (Al. 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.

2008 *Byttneriophyllum tiliifolium* (Al. Braun) Knobloch & Z. Kvaček; Worobiec et al., p. 205, 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.

Material. KRAM-P 243/A/CDisp/: 110–128, 130–136; KRAM-P 244/C/CDisp/: 12, 13.

Macromorphology. Areoles well developed, small, 0.10–0.15 mm in size. Veinlets absent. Marginal ultimate venation looped.

Micromorphology. Adaxial epidermis composed of isodiametric, occasionally slightly elongated cells, 10.0–27.5 (30.0) μm in size. Anticlinal cell walls usually thick, predominantly straight, occasionally rounded. Cuticle without or with dense reticulate ornamentation. It can not be excluded that in fact this "ornamentation" represents sculptured layer of epicuticular wax. On the adaxial epidermis trichome bases without trichomes preserved were found. Abaxial epidermis consists of variably-shaped cells, 7.5–22.5 μm in size. Anticlinal cell walls thin, usually straight, rarely rounded. Leaves hypostomatic. Stomata anomocytic, rounded to wide elliptic, variable in size, 14–24 μm in diameter. Outer stomatal ledge aperture spindle-shaped, variable in size, 7.5–16.0 μm long and 2.5–7.5 μm wide. Stomatal pore occasionally visible. Some of stomata are surrounded by cuticular striae perpendicular to them. On the abaxial epidermis two types of trichomes were found. Stellate trichomes are composed of 7–8 rays, 50–113 μm long and 5–10 μm wide with elliptic-roundish trichome base, 17.5–25.0 μm in diameter. Density of stellate trichomes depends of the specimen: from relatively seldom to very abundant, forming a dense cover. Glandular, clavate trichomes, are scattered on epidermis and composed of almost always 6 cells, measure 27.5–39.0 μm long and 17.0–22.5 μm wide. Base of clavate trichomes is elliptic-rounded, one-celled, 10–15 μm in diameter.

Remarks. Micromorphological features of these cuticular remains match accurately with cuticular data of leaf remains of *Byttneriophyllum tiliifolium* (Al. Braun) Knobloch & Z. Kvaček described earlier from the same locality (Worobiec et al. 2008). Leaf cuticles of another fossil species from family Malvaceae, *Dombeyopsis lobata* Unger differs from *Byttneriophyllum tiliifolium* in the absence of trichomes on the adaxial epidermis and in 4 to 5 celled clavate glandular trichomes on abaxial epidermis (*Byttneriophyllum* – almost always 6-celled).

Micromorphological features of epidermis of *Byttneriophyllum tiliifolium* are common in the former families Sterculiaceae and Tiliaceae (Knobloch & Kvaček 1965). Contemporary taxonomic studies including molecular investigations of Bayer et al. (1999) and Alverson et al. (1999) merged Tiliaceae and Sterculiaceae as well as Bombacaceae and Malvaceae into a single family Malvaceae Juss. (APG II 2003) or Malvaceae *sensu lato* with nine subfamilies: Byttnerioideae, Grevioideae, Tilioideae, Brownlowioideae, Helicteroideae, Sterculioideae, Dombeyoideae, Bombacoideae, and Malvoideae (Bayer & Kubitzki 2003).

Byttneriophyllum tiliifolium was a component of swampy vegetation in the Neogene flora of central Europe (Knobloch & Kvaček 1965), common in central Europe in the Middle and Late Miocene (Zastawniak et al. 1996, 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*), Trzcianka (Raniecka-Bobrowska 1970), Bełchatów (Stuchlik et al. 1990), Ruja (Worobiec et al. 2008); Late Miocene – Bełchatów (Worobiec 2003); Miocene – Kunice Żarskie (Engelhardt 1877, as *Ficus tiliaefolia* A. Br.), Rataje (Menzel 1910, as *Ficus tiliaefolia*), Wołów (Kräusel 1919, as *Büttneria aequalifolia* (Goeppert) Meyer), Zielona Góra (Kräusel 1920, as *Büttneria aequalifolia*), Pierusza, Wichów (Kräusel 1921, as *Büttneria aequalifolia*), Smogorzówek, (Raniecka-Bobrowska 1970), Nysa (Krajewska 2001).

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

Material. KRAM-P 243/A/CDisp/: 129.

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

cf. ***Dombeyopsis lobata*** Unger

Pl. 5, fig. 4

? 1850a *Dombeyopsis lobata* Unger, Unger, p. 447.
? 1976 *Dombeyopsis lobata* Unger; Knobloch & Kvaček, p. 60, Figs 25, 26, pl. 13, fig. 6, pl. 31, fig. 9, pl. 32, figs 4–8.

Material. KRAM-P 243/A/CDisp/: 220.

Micromorphology. On the very small pieces of unidentified side of epidermis, outlines of isodiametric and elongated cells, with predominantly straight anticlinal cell walls were found. Two types of trichomes were found. Stellate trichomes composed of (3)4–5 rays 75–100 μm long and 7.5–12.0 μm wide, trichome base 20–40 μm in diameter. Glandular, clavate trichomes, composed of several cells, measure about 40 μm long and 15.0–17.5 μm wide. Base of clavate trichome one-celled, elliptic, about 12 μm in diameter.

Remarks. Structure and shape of stellate trichomes (with 4–5 rays) along with shape of glandular trichomes suggest affinity with fossil species *Dombeyopsis lobata* Unger. Poor state of preservation excluded unequivocally identification of this remain.

Occurrence in the fossil floras of Poland. A leaf described as *Dombeyopsis lobata* Unger from Middle Miocene deposits of the Bełchatów Lignite Mine (Stuchlik et al. 1990) most probably represents *"Ficus" truncata* Heer sensu Bůžek.

Myricaceae A. Rich ex Kunth

Myrica L.

Myrica lignitum (Unger) Saporta *sensu lato*

Pl. 6, figs 1, 2

1847 *Quercus lignitum* Unger, p. 113, pl. 31, figs 5–7.
1865 *Myrica lignitum* (Unger) Saporta, p. 102.
2008 *Myrica lignitum* (Unger) Saporta, Worobiec et al., p. 209, Fig. 4: 5; pl. 3, fig. 7, pl. 12, figs 1, 2.

Material. KRAM-P 243/A/CDisp/: 181–185.

Micromorphology. Adaxial epidermis composed of isodiametric or elongated cells, 15.0–27.5 μm in size. Anticlinal cell walls usually straight. Cuticle strongly granular most probably due to presence of layer of epicuticular wax. Under the epidermis two-layered hypodermis was found. Upper layer consists of polygonal, large cells with straight walls, 17.5–35.0 μm in size. Lower layer is composed of small, rounded cells, 5–15 μm in diameter. Abaxial epidermis consists of irregular-shaped, polygonal cells, 14–20 μm in size. Anticlinal cell walls straight or rounded. Cuticle strongly granular most probably due to presence of layer of epicuticular wax. Leaves hypostomatic. Stomata rounded or elliptic, 20–25 μm in diameter. Outer stomatal ledge aperture narrow, 7.5–10.0 μm long and about 2.5 μm wide. Polar T-piece usually present, rather indistinct. On the abaxial epidermis numerous glandular, peltate trichomes were found. Trichome shield, 75–100 μm in diameter, multicellular, cells radially arranged, trichome base two-celled, more or less elliptic, 17.5–25.0 μm in diameter.

Remarks. Micromorphology of cuticles discussed is similar to *Myrica lignitum* (Unger) Saporta *sensu lato*. Peltate glandular trichomes with two-celled bases are typical of *Myrica* leaves. For the first time, the two-layered hypodermis of *Myrica lignitum* was described. Two-celled bases of glandular trichomes distinguish these dispersed cuticles from rather similar cuticles of leaves of *Engelhardia* Lesch. ex Bl. (Juglandaceae). *Myrica lignitum* differs from *Myrica undulatissima* Knobloch & Kvaček in mostly rounded cell walls of abaxial epidermis and rounded shields of peltate trichomes (Knobloch & Kvaček 1976). Schneider (2000) described, revised and discussed 8 taxa of dispersed cuticles from genus *Pelticutis* Schneider emend. Schneider equivalent to genus *Myrica*: *Pelticutis hungeri* (Schneider) Schneider, *P. cistomatifera* (Roselt & Schneider) Schneider, *P. joannis* (Ettingshausen emend. Kovar-Eder) Schneider, *P. undulatissima* (Knobloch & Kvaček) Schneider, *P. klettwiciensis* (Litke) Schneider, *P. crenata* (Jähnichen) Schneider, *P. holzweissigensis* (Schneider) Schneider, and *P. integerrima* Kräusel & Weyland. From these taxa *Pelticutis klettwiciensis* (Litke) Schneider (= *Myrica klettwiciensis* Litke) is most similar to *Myrica lignitum* (Unger) Saporta *sensu lato* from Ruja in respect of size and shape of ordinary epidermal cells, stomata and trichomes. Schneider (2000) included taxa "VII *Myrica sensu stricto*" (Ferguson 1971) and *Myrica lignitum* (Unger) Saporta *sensu stricto* (Knobloch & Kvaček 1976) to *Pelticutis klettwiciensis*. Considering this it is very probable that *Myrica lignitum* (Unger) Saporta *sensu lato* from Ruja and *Pelticutis klettwiciensis* (Litke) Schneider represent one taxon. However, we are strongly inclined to avoid using the artificial genus name *Pelticutis* and considering rule of priority (*M. klettwiciensis* Litke was described already in 1967) we decided to use species name *Myrica lignitum* (Unger) Saporta *sensu lato*.

Myrica lignitum was a common element

of Neogene fossil floras, an indicator of the presence of swampy vegetation.

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), Ruja (Worobiec et al. 2008); 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*.

Salicaceae Mirbel

Salix L.

Salix hausruckensis Kovar-Eder

Pl. 7, figs 1–5

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

2008 *Salix hausruckensis* Kovar-Eder; Worobiec et al., p. 211, Fig. 4: 2, 3; pl. 4, figs 4, 6, pl. 13, figs 5–7, pl. 14, figs 1, 2.

Material. KRAM-P 243/A/CDisp/: 36–48, 50–72; KRAM-P 243/B/CDisp/: 16; KRAM-P 243/E/CDisp/: 241–244; KRAM-P 244/C/CDisp/: 2–4, 14.

Macromorphology. Higher-order venation random reticulate, marginal ultimate venation looped.

Micromorphology. Adaxial epidermis composed of usually slightly elongated cells, 10–35 µm in size. Anticlinal cell walls thick, straight, occasionally rounded, often characteristic fissures of wall are visible (Pl. 7, fig. 1). Cuticle usually with striate ornamentation, sometimes rather dense. Scarce layer of granular epicuticular wax is seldom visible. Abaxial epidermis consists of isodiametric or slightly elongated cells, 12–45 µm in size. Anticlinal cell walls thick, straight, rounded, exceptionally slightly undulate. Leaves hypostomatic. Stomata distinctly variable in size, predominantly brachyparacytic, besides anomocytic, anisocytic and, especially giant stomata, cyclocytic, elliptic, rarely narrow elliptic, 12.5–32.0 µm long and 7.5–20.0 µm wide. Giant stomata often surrounded by perpendicular striae. Outer stomatal ledge aperture wide to narrow spindle-shaped, occasionally elliptic, strongly cutinized and variable in size, 7.5–25.0 µm long and 2.5–11.0 µm wide. Almost always rather distinct layer of granular epicuticular wax is visible on the cuticle of abaxial epidermis (Pl. 7, fig. 2b). On the abaxial epidermis, trichome bases, unicellular, roundish, 10–15 µm in diameter, were found. The trichomes on the abaxial epidermis are usually absent or very rare, only rarely they are more abundant. Very rarely on the adaxial epidermis the same type of trichomes were found.

Remarks. Structure of abaxial epidermis (especially stomata of a mixed type: brachyparacytic, besides anomocytic, anisocytic, and cyclocytic) matches very well only with fossil *Salix hausruckensis* Kovar-Eder described by Kovar-Eder & Wójcicki (2001) from the Late Miocene flora from Hinterschlagen in Austria. Stomata of other fossil species of *Salix* are almost always brachyparacytic.

Kovar-Eder & Wójcicki (op. cit.) considered recent Florida Willow, *Salix floridana* Chapman as most similar to the fossil *S. hausruckensis*.

Occurrence in the fossil floras of Poland. Middle Miocene – Ruja (Worobiec et al. 2008).

***Salix semihausruckensis* sp. nov.**

Pl. 8, figs 1–3

Holotype designated here. Slide KRAM-P 243/A/CDisp/: 198 (Pl. 8, figs 1a, b).

Paratype. Slide KRAM-P 243/A/CDisp/: 196 (Pl. 8, figs 2a, b).

Repository. Department of Palaeobotany, Władysław Szafer Institute of Botany, Polish Academy of Sciences, Kraków, Poland.

Type locality. Borehole Komorniki 97/72 in Ruja lignite deposit near Legnica, Lower Silesia, Poland.

Stratigraphic horizon. Lowermost part of Poznań Formation.

Age. Middle Miocene (Badenian).

Derivatio nominis. From similarity of abaxial epidermis structure to fossil willow *Salix hausruckensis* Kovar-Eder.

Further material. KRAM-P 243/A/CDisp/: 192, 194, 195, 197, 199, 204, 207–215, 218.

Diagnosis. Adaxial epidermis composed of usually elongated, often rectangular cells, anticlinal cell walls thick, usually rounded, rarely straight. Cuticle always with dense striate ornamentation. Abaxial epidermis thin, anticlinal cell walls straight, rounded, sometimes slightly minute undulate. Leaves hypostomatic. Stomata distinctly variable in size, predominantly brachyparacytic, sometimes anomocytic, elliptic, narrow elliptic, often surrounded by perpendicular striae. Outer stomatal ledge aperture spindle-shaped, narrow spindle-shaped, outer stomatal ledges strongly cutinized.

Micromorphology. Adaxial epidermis composed of usually elongated, often rectangular cells, 17.5–50.0 μm in size. Anticlinal cell walls thick, usually rounded, rarely straight. Cuticle always with dense striate ornamentation, striae sometimes additionally undulate, not so long and usually thin. Abaxial epidermis thin, cells 17.5–32.5 μm in size. Anticlinal cell walls usually almost invisible, straight, rounded, sometimes slightly minute undulate. Leaves hypostomatic. Stomata distinctly variable in size, predominantly brachyparacytic, sometimes anomocytic, elliptic, narrow elliptic, 17.5–27.5 μm long and 11–20 μm wide. Stomata often surrounded by perpendicular striae. Outer stomatal ledge aperture spindle-shaped, narrow spindle-shaped, outer stomatal ledges strongly cutinized, 10.0–22.5 μm long and 2.5–10.0 μm wide.

Remarks. The dispersed cuticles are similar to fossil *Salix hausruckensis* Kovar-Eder described by Kovar-Eder & Wójcicki (2001) from the Late Miocene flora from Hinterschlagen in Austria. These remains have typical structure of abaxial epidermis (stomata of mixed type: brachyparacytic and anomocytic) for *Salix hausruckensis*. However, it differs in densely striated cuticle and mostly rounded anticlinal cell walls of adaxial epidermis and surprisingly thin abaxial epidermis without distinct layer of epicuticular wax. It could not be excluded that these dispersed cuticles could represent a new ecotype of *Salix hausruckensis*, but in authors' opinion these differences are significant and allow erection a new taxon, *Salix semihausruckensis*. Probably it was closely related to *Salix hausruckensis*.

Salix varians Goeppert *sensu lato*

Pl. 8, figs 4–5, Pl. 9, figs 1–3

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

2008 *Salix varians* Goeppert *sensu lato*; Worobiec et al., p. 212, Fig. 4: 6; pl. 4, figs 3, 5, pl. 14, figs 3, 4.

There are two micromorphotypes:

Morphotype A: (Pl. 8, figs 4–5)

Material. KRAM-P 243/A/CDisp/: 73–93, 137–180, 221.

Micromorphology. Adaxial epidermis composed of isodiametric, polygonal (5–7 sided), occasionally elongated cells, 12.0–37.5 μm in size. Anticlinal cell walls rather thick, predominately straight, occasionally rounded. Striate ornamentation of cuticle exceptionally found. Abaxial epidermis consists of usually slightly elongated cells, 15–30 μm in size. Anticlinal cell walls thick, straight or rounded. Layer of epicuticular wax of conicoidal structure, usually very abundant and thus sometimes making the outlines of epidermal cells hardly traceable is visible on the cuticle of abaxial epidermis. Leaves hypostomatic. Stomata regularly brachyparacytic, exceptionally cyclocytic (giant stomata), elliptic, narrow elliptic, 11–20 μm long and 7.5–12.5 μm wide. Giant stomata sometimes visible. Outer stomatal ledge aperture distinctly variable in size, spindle-shaped or narrow spindle-shaped, strongly cutinized, 7.5–17.5 μm long and 2.5–6.0 μm wide. Unicellular, elliptic to rounded trichome bases, 10–15 μm in diameter, surrounded by few cells were found on the abaxial epidermis, on the adaxial epidermis similar trichome bases were virtually never found.

Morphotype B: (Pl. 9, figs 1–3b)

Material. KRAM-P 243/A/CDisp/: 94–109.

Micromorphology. Adaxial epidermis composed of usually isodiametric, polygonal (4–7 sided), occasionally slightly elongated cells (over the veins more elongated), 9.0–20.5 (25) μm in size. Anticlinal cell walls strongly cutinised, very thick, predominately straight, occasionally rounded. Abaxial epidermis consists of usually slightly elongated cells, 12.5–30.0 μm in size. Anticlinal cell walls very thick, straight, rarely rounded. Cuticle is covered by layer of epicuticular wax of conicoidal structure, usually very abundant and thus sometimes making the outlines of epidermal cells hardly traceable (Pl. 9, fig. 3a). Leaves hypostomatic. Stomata regularly brachyparacytic, elliptic, narrow elliptic, 10–20 μm long and 7.5–14.0 μm wide. Giant stomata sometimes visible. Outer stomatal ledge aperture spindle-shaped or narrow spindle-shaped, strongly cutinized, 7.5–15.0 μm long and 4.0–7.5 μm wide. Unicellular, usually not abundant, strongly cutinised, elliptic to rounded trichome bases, 5–10 μm in diameter, surrounded by 4 to 7 cells, were found both on the adaxial and abaxial epidermis.

Remarks. The micromorphology of the cuticles allowed their identification as *Salix varians* Goeppert (Knobloch & Kvaček 1976, Mai & Walther 1978, Belz & Mosbrugger 1994, Kovar-Eder & Meller 2003). Two micromorphological morphotypes of cuticles of *Salix varians* were found in the investigated material from Ruja. Differences between them are mainly in size of the cells of adaxial epidermis and diameter of trichome bases on the abaxial epidermis. Similar micromorphological differences in cuticles of *Salix varians* were observed in the earlier investigated fossil leaves of this willow from the Ruja locality (Worobiec et al. 2008). Morphotype A described above correspond to serrate leaves of *Salix varians* described earlier from Ruja and morphotype B to entire-margined leaves respectively. This observation confirms opinion of Worobiec et al. (op. cit.) that *Salix varians* is very probably a collective species (*sensu lato*) of two or even more taxa. This willow shows also a considerable morphological variation of leaves (Krajewska 1998).

Also very interesting is presence of well preserved remains of epicuticular wax layer on the abaxial epidermis. Micromorphology of epicuticular waxes in *Salix varians* (Pl. 9, fig. 3a, b) shows conicoidal structure typical of *Salix* (Tomaszewski 2004).

Salix varians is common species in the Paleogene and Neogene floras of Europe from Oligocene to Pliocene (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), Ruja (Worobiec et al. 2008); Late Miocene – Sośnica (sub *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).

Fagaceae Dumortier

(?) **Castanea** Miller

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

Pl. 9, figs 4–6, Pl. 10, fig. 1

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, p. 35, Figs 13, 14, pl. 16, figs 7–9, pl. 18, figs 1, 4–10, pl. 23, figs 4, 6, 8–11, pl. 31, fig. 7
2008 *"Castanea" kubinyii* Kováts ex Ettingshausen sensu Knobloch & Z. Kvaček; Worobiec et al., p. 215, Fig. 5: 9, 10; pl. 5, fig. 3, pl. 7, fig. 4, pl. 15, fig. 2.

Material. KRAM-P 243/E/CDisp/: 1–64, 68, 186/I, 199.

Micromorphology. Adaxial epidermis composed of mostly polygonal cells, 25–50 μm in size. Anticlinal cell walls straight, rarely rounded. Abaxial epidermis consists of isodiametric and slightly elongated cells, 15.0–42.5 μm in size. Anticlinal cell walls shape vary depending on the specimen: straight, rounded, undulate, occasionally strongly undulate, but predominantly undulate. Leaves hypostomatic. Stomata anomocytic, elliptic, 17.5–25.0 μm (commonly 20.0–22.5 μm) long and 15.0–17.5 μm wide. Outer stomatal ledge aperture narrow elliptic-oblongate, 6.0–7.5 μm long and 2.5–4.0 μm wide. Stomatal pore usually visible. Polar T-piece usually visible. On the abaxial epidermis scattered unicellular trichome bases, 10.0–12.5 μm in diameter are found. Only two trichomes were preserved, two-rayed, rays 62.5–75.0 μm long and about 12 μm wide, apices of rays acute (Pl. 10, fig. 1).

Remarks. Dispersed cuticles described above are characteristic for species *"Castanea" kubinyii* Kováts ex Ettingshausen sensu Knobloch & Z. Kvaček (Knobloch & Kvaček 1976, Bůžek et al. 1996, Knobloch & Kvaček 1996, Hably & Kvaček 1997, Kovar-Eder & Wójcicki 2001, Worobiec 2003, Worobiec et al. 2008). Typical for this species is complete absence of stellate trichomes in abaxial epidermis. This feature differentiates epidermis of *"Castanea" kubinyii* from macro- and micromorphologically similar fossil oak, *Quercus gigas* Goepp. emend. Walther & Zastawniak which has numerous stellate trichomes. The authors support the opinion of others that it is not possible to distinguish fossil leaves of the genera *Quercus* and *Castanea* on the basis of either morphology or anatomy (Ferguson 1971, Knobloch & Kvaček 1976, Worobiec et al. 2008) and it is unclear whether the leaves of *"Castanea" kubinyii* belong to oak or chestnut.

Occurrence in the fossil floras of Poland. Lower Miocene – Bełchatów (Worobiec 1995, 2003); Middle Miocene – Ruja (Worobiec et al. 2008).

Dicotyledones incertae sedis

Dicotylophyllum rujense **sp. nov.**

Pl. 10, figs 2–3

Holotype designated here. Slide KRAM-P 243/B/CDisp/: 5 (Pl. 10, figs 3a, b).

Paratype. Slide KRAM-P 243/B/CDisp/: 10.

Repository. Department of Palaeobotany, Władysław Szafer Institute of Botany, Polish Academy of Sciences, Kraków, Poland.

Type locality. Borehole Komorniki 97/72 in Ruja lignite deposit near Legnica, Lower Silesia, Poland.

Stratigraphic horizon. Pawłowice Formation.

Age. Middle Miocene (Badenian).

Derivatio nominis. From the name of the Ruja lignite deposit, where this species has been discovered.

Further material. KRAM-P 243/B/CDisp/: 1–4, 6–9, 11.

Diagnosis. Adaxial epidermis consists of usually isodiametric, sometimes slightly elongated cells, anticlinal cell walls undulate. Cuticle with randomly oriented striae ornamentation. Abaxial epidermis composed of isodiametric or elongated cells, over the veins cells are distinctly elongated, rectangular. Anticlinal cell walls usually undulate, sometimes rounded. Cuticle around stomata covered by layer of granular epicuticular wax. Leaves hypostomatic. Stomata cyclocytic and anomocytic, rounded to wide elliptic, polar T-piece usually present, not distinct. Outer stomatal ledge aperture elliptic, sometimes rounded, stomatal pore usually visible, thin. On the adaxial (very rare) and abaxial (frequently) epidermis unicellular trichome bases were found.

Micromorphology. Adaxial epidermis consists of usually isodiametric, sometimes slightly elongated cells, 22.5–50.0 μm in size. Anticlinal cell walls undulate. Cuticle with randomly oriented striated ornamentation. Abaxial epidermis composed of isodiametric or elongated cells, 15.0–42.5 μm in size, over the veins cells are distinctly elongated, rectangular. Anticlinal cell walls usually undulate, sometimes rounded. Cuticle around stomata covered by layer of granular epicuticular wax. Leaves hypostomatic. Stomata cyclocytic and anomocytic, rounded to wide elliptic, 20.0–27.5 μm in diameter. Polar T-piece usually present, dot distinct. Outer stomatal ledge aperture elliptic, sometimes rounded, 7.5–14.0 μm long and 6–10 μm wide. Stomatal pore usually visible, thin. On the adaxial (very rare) and abaxial (frequently) epidermis unicellular, trichome bases, about 17 μm in diameter were found.

Remarks. Systematic position of the dispersed cuticles described above is unknown. Slightly similar morphotypes of cuticles could be observed in fossil *Lusaticutis rugosa* Schneider (Schneider 1992), *Myrsine miocenica* Juchniewicz (Juchniewicz 1975a) and *Skimia tortonica* Palamarev & Usunova (Usunova 1995). However, all discussed taxa differ in respect of micromorphology of adaxial and abaxial cuticle from *Dicotylophyllum rujense*. *Myrsine miocenica* has a different type of stomatal complex (anisocytic) and lacks of striae on adaxial epidermis, *Lusaticutis rugosa* has a different type of stomatal complex and *Skimia tortonica* differs in straight-walled adaxial epidermis without cuticular striae.

***Dicotylophyllum* sp. 1**

Pl. 10, fig. 4

Material. KRAM-P 243/A/CDisp/: 206.

Micromorphology. Adaxial epidermis composed of usually elongated cells, often rectangular, 20–40 μm in size. Anticlinal cell walls thin, rounded, fine undulate, rarely straight. Abaxial epidermis consists of isodiametric and elongated cells, 20.0–27.5 μm in size. Anticlinal cell walls straight, rounded, slightly undulate, very thin and so hardly visible. Leaves hypostomatic. Stomata elliptic, 16–25 μm long and 10.0–17.5 μm wide. Outer stomatal ledge aperture spindle-shaped, occasionally elliptic, 10.0–17.5 μm long and 4.0–7.5 μm wide.

Remarks. Systematic position unknown due to absence of distinctive features.

***Dicotylophyllum* sp. 2**

Pl. 11, fig. 1

Material. KRAM-P 243/A/CDisp/: 188.

Micromorphology. Adaxial epidermis consists of isodiametric, or slightly elongated cells, 27–50 μm in size, over the veins more elongated. Anticlinal cell walls undulate, over the veins rounded or slightly undulate. Abaxial epidermis cells, 25–50 μm in size with straight or rounded anticlinal cell walls. Leaves hypostomatic. Stomata elliptic, 17.5–20.0 μm in diameter. Outer stomatal ledge aperture hardly visible, narrow or very narrow spindle-shaped, 7.5–12.5 μm long. Several probably idioblast secretory cells were found, more or less round in shape, 25.0–27.5 μm in diameter.

Remarks. Systematic position unknown. Similar cuticular structures are observed in fossil and recent species of the Lauraceae family. The undulation of walls of cells of adaxial epidermis and the shape of stomata particularly resemble epidermis of leaves of the morphogenus *Daphnogene*. However, cells of adaxial epidermis of *Dicotylophyllum* sp. 2 are twice as big as in leaves of *Daphnogene polymorpha* (Al. Braun) Ettingshausen from Bełchatów (Worobiec 2003) and in addition the structure of stomatal complex of *Dicotylophyllum* sp. 2 is unknown and consequently not possible to be compared with paracytic stomata of *Daphnogene*.

***Dicotylophyllum* sp. 3**

Pl. 11, fig. 2

Material. KRAM-P 243/E/CDisp/: 202, 219(?).

Micromorphology. Adaxial epidermis consists of usually rectangular, sometimes polygonal cells, 15–25 μm in size, over the veins more elongated. Anticlinal cell walls almost always straight. Cuticle granular. Leaves hypostomatic. Stomata probably anomocytic (?), rounded of wide elliptic, 15–19 μm in diameter. Outer stomatal ledge aperture wide spindle-shaped, 9–10 μm long and 5.0–7.5 μm wide.

Remarks. No similar forms were found in available literature and comparable material. Systematic position unknown.

***Dicotylophyllum* sp. 4**

Pl. 11, fig. 3

Material. KRAM-P 243/E/CDisp/: 216–218.

Micromorphology. Abaxial epidermis composed of isodiametric or slightly elongated cells, 12.5–25.0 μm in size. Anticlinal cell walls thin, rounded. Cuticle granular (probably layer of epicuticular wax). Stomata elliptic, narrow elliptic, 25–30 μm long and 12.5–15 μm wide. Stomata are surrounded by cuticular striae perpendicular to them. Outer stomatal ledge aperture wide to narrow spindle-shaped, 17.5–25.0 μm long and 4.0–12.5 μm wide.

Remarks. Systematic position unknown due to absence of distinctive features.

Dicotyledones indeterminatae

Pl. 11, figs 4, 5

Material. KRAM-P 243/A/CDisp/: 189–191, 193, 200–203, 205, 216, 217, 219; KRAM-P 243/B/CDisp/: 12; KRAM-P 243/E/CDisp/: 108, 109, 112–119, 121–127, 129, 131–142, 144–157, 183, 189–191, 198, 203, 205–210, 220, 221; KRAM-P 244/C/CDisp/: 11.

KRAM-P 243/A/CDisp/189, 190, 193, 203, 205, 216 – could belong to *Salix*

KRAM-P 243/A/CDisp/201 – could belong to *Myrica*

Remarks. The described dicotyledonous

cuticles have been preserved in so poor state that determination of their systematic position is impossible.

Monocotyledones

Zingiberaceae Martynov

Zingiberoideophyllum Kräusel & Weyland

Zingiberoideophyllum liblarense Kräusel & Weyland

Pl. 12, figs 1, 2

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

2008 *Zingiberoideophyllum liblarense* Kräusel & Weyland; Worobiec et al., p. 220, pl. 4, fig. 9, pl. 7, fig. 6, pl. 17, figs 2, 3.

Material. KRAM-P 243/A/CDisp/: 1–12.

Macromorphology. Higher order venation parallel, veins are spaced 0.20–0.35 mm apart, numerous cross (transverse) veins connect adjacent parallel veins and form with them square or short rectangular areoles, 0.15–0.30 (0.40) mm long. Numerous black spots are visible inside mesophyll, most probably representing remnants of secretory cells content. Also probably fruiting bodies of fungi were found inside or on surface of leaf fragments.

Micromorphology. Adaxial epidermis not prepared successfully. Abaxial epidermis consists of usually elongated, irregular-rectangular, diversified cells: cells between stomatal bands are longer than belonging to stomatal bands. Cells are 19.0–67.5 μm long and 10.0–12.5 μm wide. Arrangement of cells more or less longitudinal. Anticlinal cell walls rounded or wide undulate. Remnants of hypodermis are visible under epidermis, cells thin-walled. Stomata arranged in stomatal bands, parallel to the leaf venation, composed of 3–4 rows of stomata between each vein. Stomata tetracytic, wide elliptic to rounded, 22.5–29.0 × 27.5–35.0 μm. 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 usually narrow spindle-shaped, 17.5–30.0 μm long and 6–16 μm wide, stomatal ledges strongly cutinized.

Remarks. Micromorphology of above described remains (tetracytic stomata arranged in stomatal bands, shape and arrangement of abaxial epidermal cells) are characteristic of the species *Zingiberoideophyllum liblarense* (Kräusel & Weyland 1954).

Occurrence in the fossil floras of Poland. Middle Miocene – Ruja (Worobiec et al. 2008); Late Miocene – Bełchatów (Worobiec & Lesiak 1998). Other representatives of family Zingiberaceae were found in the Middle Miocene deposits of Dobrzyń on the Vistula River (Kownas 1956, 1959).

? Araceae Jussieu

Dioscoreophyllum Kräusel & Weyland

Dioscoreophyllum liblarense Kräusel & Weyland complex sensu Kvaček & Wilde 2006

Pl. 12, fig. 3, Pl. 13, figs 1–3, Pl. 14, figs 1, 2

1957 *Dioscoreophyllum liblarense* Kräusel & Weyland; Weyland, p. 62, pl. 9, fig. 8, pl. 10, figs 3–9, pl. 11, figs 1–8, pl. 12, figs 1–3.

1963 *Dioscorea liblarensis* (Kräusel & Weyland) Peters, fig. 4, pl. 5, figs 28–31.

1966 *Dioscorea liblarensis* (Kräusel & Weyland) Peters; Litke, p. 351, pl. 14, figs 1–3, 5, 6, pl. 15, figs 1, 2.

1969 *Rimilatericutis tenuis* Roselt & Schneider, p. 81, fig. 31, pl. 19, fig. 2.

2006 *Dioscoreophyllum liblarense* Kräusel & Weyland complex, Kvaček & Wilde, p. 147, pl. 3, fig. 1.

2008 cf. *Varipilicutis liblarensis* (Kräusel & Weyland) Schneider; Worobiec et al., p. 222, pl. 18, fig. 4.

Material. Morphotype 1: KRAM-P 244/C/CDisp/: 1.

Micromorphology. Epidermis consists of elongated, rectangular cells, up to 232 μm long and 20–30 μm wide. Anticlinal cell walls almost always straight, thick, with perpendicular and oblique end walls. Cuticle with aggregations of epicuticular wax crystalloids (Pl. 12, fig. 3c). Stomata brachyparacytic, regularly elliptic, 64–74 μm long and about 30 μm wide. Stomata oriented with parallel longer axes. Outer stomatal ledge aperture narrow spindle-shaped, 49.5–57.0 μm long and about 15 μm wide.

Material. Morphotype 2: KRAM-P 244/B/CDisp/: 1 (pro parte), 2 (pro parte), 4 (pro parte); Morphotype 3: KRAM-P 244/B/CDisp/: 2 (pro parte); Morphotype 4: KRAM-P 244/B/CDisp/: 3, 4 (pro parte); Transitional forms between morphotypes 2, 3 and 4: KRAM-P

244/B/CDisp/: 1 (pro parte), 2 (pro parte), 4 (pro parte).

Macromorphology. Cross (transverse) veins connect adjacent parallel veins, cross veins are oriented obliquely to them and form more or less rhomboidal, well developed areole.

Micromorphology. Leaves probably amphistomatic. Adaxial epidermis consists of isodiametric and elongated cells, 54.5–99.0 μm in size. Anticlinal cell walls usually straight, thick. Cuticle with aggregations of epicuticular wax crystalloids (Pl. 13, figs 1a–c, Pl. 14, fig. 2a). Abaxial epidermis consist of slightly (in morphotype 3) or strongly elongated rectangular cells, 45–114 (morphotype 3) and 49.5–163.0 μm long and 25–35 μm wide (morphotypes 2, 4). Anticlinal cell walls straight, rarely rounded, thick and in morphotype 4 perforated. Cuticle with very distinct ornamentation in form of knobs-tubercle, and in morphotype 4 with aggregations of epicuticular wax crystalloids. Stomata paracytic, elliptic, elliptic-elongated, 57–74 μm long and 20–40 μm wide. Stomata oriented, longer axis of stomata parallel to the leaf venation. In morphotype 2 stomata sometimes surrounded by striae. Outer stomatal ledge aperture wide to narrow spindle-shaped, strongly cutinised, 45–59 μm long and 12–25 μm wide.

On the epidermis of the most of specimens were found rests of fungal hyphae and fruiting bodies (Pl. 12, figs 3b–d). Presence of similar fungal remains on cuticles of this type was also reported by earlier authors (see Kvaček & Wilde 2006).

Remarks. The discussed dispersed cuticles belong to the cuticular complex of *Dioscoreophyllum liblarense* Kräusel & Weyland sensu Kvaček & Wilde (Kvaček & Wilde 2006). Kvaček and Wilde (op. cit.) mentioned that Weyland (1957) added to description of *Dioscoreophyllum liblarense* heterogeneous group of cuticular fragments mostly of monocotyledonous affinity. The dispersed cuticles described by Weyland have mostly paracytic stomata that vary in size and form. Similar differences, mostly in shape of epidermal cells are visible in cuticular material from Ruja. Kvaček and Wilde (2006) also mentioned that later records of cuticular material of the *Dioscoreophyllum liblarense* type maintained this unnatural unit of morphotypes. Finally, Kvaček and Wilde (op. cit.) confirmed monocotyledonous nature of these cuticles, but exact affinities of *Dioscoreophyllum liblarense* complex remain uncertain to them. Like Weyland (1959), they confirmed that *Dioscoreophyllum* is surely not related to Dioscoreaceae. Schneider (1969a, 2004) discussed micromorphological features of *Dioscoreophyllum liblarense* and also rejects its assignment to the family Dioscoreaceae. For dispersed cuticles found in Miocene lignite deposits from Lusatia, Germany, he created a new combination *Varipilicutis liblarensis* (Kräusel & Weyland) Schneider. However, contrary to material from Ruja, cuticles from Nochten correspond to type material of *Dioscoreophyllum liblarense* (Kräusel & Weyland 1954, see Kvaček & Wilde 2006) and not to the *Dioscoreophyllum liblarense* complex sensu Weyland (1957), Peters (1963) and Litke (1966). The morphotype 2, 3, 4 complex from Ruja is similar partly to *Dioscoreophyllum liblarense* complex described by Litke (1966, pl. 15 figs 1, 2, as *Dioscorea liblarensis* (Kräusel & Weyland) Peters. On the other hand, dispersed cuticles described as *Rimilatericutis tenuis* by Roselt and Schneider (1969) from the Miocene of Wiesa, considered to be possibly related to *Dioscoreophyllum liblarense* (Roselt & Schneider 1969, Kvaček & Wilde 2006) correspond exactly to the morphotype 1 from Ruja. Details of venation network of preserved leaf fragments of dispersed cuticles discussed and micromorphology of them suggest affinity with Alismatales and possibly with the family Araceae. Fossil leaves of Araceae with similar higher order venation and cuticles were described by Wilde et al. (2005) as *Araciphyllites tertiarius* (Engelhardt) Wilde, Z. Kvaček & Bogner from the Middle Eocene of Messel, Germany. It should be emphasized that in *Araciphyllites tertiarius* variability of cuticles could be observed. There are *Araciphyllites* Wilde, Z. Kvaček & Bogner cuticles from midvein with parallel arranged elongated rectangular cells and stomata and cuticles of intercostal area with short epidermal cells and scattered subparallel stomata. Very similar variability of cuticles is visible in the morphotypes 2, 3 and 4 of the *Dioscoreophyllum* complex from Ruja. Considering this, it could not to be excluded that differences observed between morphotypes 2, 3 and 4 resulted from different location of source area of cuticles on the surface of leaf (midvein, intercostal area, petiole) or even they could derive from stem. From early Miocene of

Turów, Poland was described dispersed cuticle considered as Araceae affinity as *Araceophyllum elongatum* Juchniewicz (Juchniewicz 1975a). It differs from *Dioscoreophyllum liblarense* from Ruja in considerably smaller epidermal cells. However, morphology of stomatal complex and structure of anticlinal cell walls are rather similar both in *Araceophyllum* and *Dioscoreophyllum liblarense* and confirm affinity of *Araceophyllum elongatum* with family Araceae.

Occurrence in the fossil floras of Poland. Middle Miocene – Ruja (partly, as ? *Varipilicutis liblarensis* (Kräusel & Weyland) Schneider, Worobiec et al. 2008).

? Scheuchzeriaceae F. Rudolphi

? ***Scheuchzeria*** L.

cf. ***Scheuchzeria*** sp.

Pl. 14, fig. 3

Material. KRAM-P 243/A/CDisp/: 223, 241.

Micromorphology. Unspecified side of epidermis consists of elongated, rectangular cells, 87.5–225.0 µm long and 12.5–20.0 µm wide. Anticlinal cell walls straight, thick (thickness of wall - about 2.5 µm). Cuticle granular (probably due to epicuticular wax). Remnants of probably hypodermis are visible under epidermis, cells thin-walled, 87–100 µm long and 25–45 µm wide. Stomata rarely found, paracytic, scattered on epidermis, oriented parallel, shape not always regular, usually elliptic to wide elliptic, about 27 µm long and 22–25 µm wide. Outer stomatal ledges strongly cutinized, dual, ca. 22 µm long and 10 µm wide. Enigmatic structure resembling papilla or one-celled trichome or even fungal body was found on epidermis.

Remarks. Cuticles of similar micromorphology were observed in recent *Scheuchzeria palustris* L. (see pl. 20, fig. 6 in Juchniewicz 1975a). Due to some differences observed between the discussed cuticle and recent *Scheuchzeria*, taxonomic position of material from Ruja could not be surely determined. Dispersed cuticles described as *Scheuchzeria rhenana* (Kräusel & Weyland) Juchniewicz from Early Miocene of Turów (Juchniewicz 1975a) differs markedly in epidermal cells network and structure of stomatal complex from cuticle from Ruja.

Occurrence in the fossil floras of Poland. To date this cuticular morphotype has not been reported from the Paleogene and Neogene of Poland.

Animal cuticles

Pl. 14, fig. 4

Material. KRAM-P 243/A/CDisp/: 49; KRAM-P 243/E/CDisp/: 237.

Remarks. Fragments of animal cuticles probably of arthropod origin.

Incertae sedis

Pl. 15, figs 1–6, Pl. 16, figs 1–7

Material. KRAM-P 243/A/CDisp/: 222 (Pl. 15, fig. 1).

Description. Cuticles of angiospermous plant, badly preserved. One side without outlines of cells and with dense reticulate ornamentation. The other side composed of elongated cells with strongly undulated cell walls.

Remarks. State of preservation and absence of distinctive features (e.g. stomata) excluded determination of systematic position.

Material. KRAM-P 244/C/CDisp/: 5 (Pl. 15, fig. 2).

Description. Epidermal cells usually elongated, cell walls rounded or slightly undulated. Scattered stomata anomocytic, wide elliptic or roundish. Outer stomatal ledge aperture narrow elliptic.

Remarks. Rarely distributed stomata suggest that the epidermal fragment described above could represented epidermis of flower petal or adaxial epidermis of leaf. Absence of distinctive features excluded determination of systematic position.

Material. KRAM-P 243/A/CDisp/: 222, 224–226, 228–231, 235, 237–240, 242, 243; KRAM-P 243/E/CDisp/: 196, 200, 201, 212–215, 223–236; KRAM-P 244/B/CDisp/: 5, 6; KRAM-P 244/C/CDisp/: 7–11.

Description. Fragments of various plant tissues, not of cuticular origin.

Remarks. Determination of systematic position excluded due to lack of distinctive features.

Material. KRAM-P 243/A/CDisp/: 227, 232–234, 236 (Pl. 15, fig. 3).

Description. Fragments of plant bodies, probably roots.

Remarks. Determination of systematic position excluded due to lack of distinctive features.

RESULTS OF TAXONOMIC INVESTIGATIONS ON DISPERSED CUTICLES

As a result of the investigation of 526 slides of dispersed cuticles from the Komorniki 97/72 and 97/73 cores, 19 taxa of genera *Acer*, *Alnus*, *Byttneriophyllum*, *"Castanea"*, *Dicotylophyllum*, *Dioscoreophyllum*, *?Dombeyopsis*, *Glyptostrobus*, *Myrica*, *Osmunda*, *Salix*, *?Scheuchzeria*, and *Zingiberoideophyllum* representing families ?Araceae, Betulaceae, Cupressaceae, Fagaceae, Malvaceae, Myricaceae, Osmundaceae, Salicaceae, Sapindaceae, ?Scheuchzeriaceae, and Zingiberaceae were found.

Two new taxa were described: *Salix semihausruckensis* sp. nov. and *Dicotylophyllum rujense* sp. nov.

Fungal remains (Pl. 16, fig. 8) were found on leaf cuticles (ascomata and fungal fruiting bodies with preserved mycelia, which will be described in a separate paper), as were very rare animal cuticles of probably arthropod origin.

The taxonomic diversity of dispersed cuticle assemblages is variable: from one taxon in horizon 102–105 m from borehole 97/73 (KRAM-P 244/B) to 12 taxa in horizon 77–78 m from borehole 97/72 (KRAM-P 243/A). The taxonomic composition of the plant assemblages of macroremains and dispersed cuticles found in the investigated cores is listed in Tables 1 and 2.

TAPHONOMY

The samples of fossil leaf litter are composed of a mixture of humified indeterminate plant detritus with addition of twigs, fragments of leaf blades and, very rarely, carpological remains. This kind of litter could result from very rapid accumulation of dead parts of plants that grew in vegetation surrounding abandoned channels, as the result of seasonal leaf fall or storm destructions of trees and subsequently transportation by rainfall or flood waters into sedimentary reservoirs, and mass deposition on bottom of them (Worobiec et al. 2008). State of preservation suggests strong compaction of litter.

COMPARISON OF DISPERSED CUTICLE ASSEMBLAGES WITH MACROREMAINS ASSEMBLAGES FROM RUJA

The taxonomic composition of assemblages of dispersed cuticles from Ruja is here compared with the results of investigations on macroremains (Worobiec et al. 2008).

Assemblages of dispersed cuticles and macroremains from the horizon KRAM-P 243/A (Tab. 1) are similar in respect of taxonomic composition. Only two species, *Sequoia abietina* and *Phragmites oehningensis* were absent among dispersed cuticles. Most probably delicate remains of leaves of *Phragmites oehningensis* did not survive maceration of leaf litter or simply were not preserved during fossilization. Absence of resistant remains of *Sequoia* could be explained by (temporary?) absence of this species during the period of accumulation of leaf litter. On the other hand, the presence of the genera of *Byttneriophyllum* and *Zingiberoideophyllum* was confirmed by the identification of cuticles, as leaf macroremains could only be identified provisionally. Analysis of the dispersed cuticles from horizon KRAM-P 243/A revealed also presence of probable *Scheuchzeria* remains and allowed description of a new fossil species of willow, *Salix semihausruckensis* sp. nov., most probably closely related to the earlier described *Salix semihausruckensis* Kovar-Eder (Kovar-Eder & Wójcicki 2001).

Comparison of taxonomic composition of macroremains and dispersed cuticle assemblages from horizon KRAM-P 243/B (Tab. 1) reveals distinct differences between them. In the dispersed cuticles assemblage remains of many taxa found as macroremains (*Acer*, *Byttneriophyllum*, *Cyperacites*, *Woodwardia*) are lacking. These differences result from nature of fossil leaf litter from which investigated cuticles were isolated. Fossil litter from horizon KRAM-P 243/B consists of mainly twigs of *Glyptostrobus europaeus* mixed with indeterminate plant detritus and only with small

Table 1. Comparison of macroremains (Worobiec et al. 2008) and dispersed cuticles (this paper) assemblages from borehole Komorniki 97/72

Horizon from depth 78–79 m (KRAM-P 243/A)	
Macroremains	Dispersed cuticles
Osmunda parschlugiana	*Osmunda parschlugiana*
Glyptostrobus europaeus	*Glyptostrobus europaeus*
Glyptostrobus vel *Sequoia*	–
Sequoia abietina	–
cf. *Byttneriophyllum tiliifolium*	*Byttneriophyllum tiliifolium*
–	cf. *Dombeyopsis lobata*
Myrica lignitum	*Myrica lignitum*
Salix hausruckensis	*Salix hausruckensis*
–	*Salix semihausruckensis* sp. nov.
Salix sp.	–
Salix sp. 1	–
Salix varians	*Salix varians*
–	*Dicotylophyllum* sp. 1
–	*Dicotylophyllum* sp. 2
–	Dicotyledones indeterminatae
Phragmites oehningensis	–
–	cf. *Scheuchzeria* sp.
cf. *Zingiberoideophyllum liblarense*	*Zingiberoideophyllum liblarense*
–	Incertae sedis

Horizon from depth 105–106 m (KRAM-P 243/B)	
Macroremains	Dispersed cuticles
Woodwardia muensteriana	–
Glyptostrobus europaeus	*Glyptostrobus europaeus*
Acer tricuspidatum	–
Alnus julianiformis	*Alnus julianiformis*
Alnus menzelii	*Alnus menzelii*
Byttneriophyllum tiliifolium	–
cf. *Myrica lignitum*	–
Salix hausruckensis	*Salix hausruckensis*
Salix sp.	–
–	*Dicotylophyllum rujense* sp. nov.
Dicotylophyllum sp. 1	–
Dicotyledones incertae sedis	Dicotyledones indeterminatae
Cyperacites sp.	–
Incertae sedis	–

Horizon from depth 117 m (KRAM-P 243/E)	
Macroremains	Dispersed cuticles
Osmunda parschlugiana	*Osmunda parschlugiana*
Glyptostrobus europaeus	*Glyptostrobus europaeus*
–	*Acer* sp.
–	*Alnus julianiformis*
–	*"Castanea" kubinyii*
–	*Salix hausruckensis*
–	*Dicotylophyllum* sp. 3
–	*Dicotylophyllum* sp. 4
–	Dicotyledones indeterminatae
–	Incertae sedis

admixture of small remains of angiospermous leaf blades. A new fossil species of dispersed cuticle, *Dicotylophyllum rujense* sp. nov. was described from horizon KRAM-P 243/B.

In contrast to the KRAM-P 243/A and KRAM-P 243/B horizons, the assemblage of dispersed cuticles from horizon KRAM-P 243/E (Tab. 1) is more abundant in species than the macroremain assemblage. Besides *Osmunda parschlugiana* and *Glyptostrobus europaeus* forming the macroremains assemblage, *Acer* sp., *Alnus julianiformis*, *"Castanea" kubinyii* and *Salix hausruckensis* and a diversified complex of indeterminate dicotyledons were found

Table 2. Comparison of macroremains (Worobiec et al. 2008) and dispersed cuticles (this paper) assemblages from borehole Komorniki 97/73

Horizon from depth 102–105 m (KRAM-P 244/B)	
Macroremains	Dispersed cuticles
Glyptostrobus europaeus	–
Acer sp.	–
Acer sp. ex gr *Rubra*	–
Acer tricuspidatum	–
Alnus menzelii	–
Byttneriophyllum tiliifolium	–
cf. *"Ficus" truncata*	–
cf. *Carpinus grandis*	–
cf. *Populus* sp.	–
Myrica lignitum	–
Populus populina	–
Salix cf. *kicktonii*	–
Salix hausruckensis	–
Salix sp.	–
Salix varians	–
Ulmus pseudopyramidalis	–
Ulmus sp.	–
Ulmus vel Zelkova	–
Zelkova zelkovifolia	–
Dicotyledones incertae sedis	–
Phragmites oehningensis	–
–	*Dioscoreophyllum liblarense* complex
Incertae sedis	Incertae sedis

Horizon from depth 107–110 m (KRAM-P 244/C)	
Macroremains	Dispersed cuticles
Glyptostrobus europaeus	*Glyptostrobus europaeus*
"Ficus" truncata	–
Alnus menzelii	–
Byttneriophyllum tiliifolium	*Byttneriophyllum tiliifolium*
Cercidiphyllum (?) *crenatum*	–
Nyssa ornithobroma	–
Salix hausruckensis	*Salix hausruckensis*
Salix sp.	–
Ulmus sp.	–
Dicotylophyllum sp. 2	–
Dicotylophyllum sp. 3	–
Dicotyledones incertae sedis	Dicotyledones indeterminatae
Hydrocharitaceae gen. indet.	–
Spirematospermum wetzleri	–
Zingiberoideophyllum liblarense	–
cf. *Varipilicutis liblarensis*	*Dioscoreophyllum liblarense* complex
–	Incertae sedis

in the dispersed cuticle assemblage from the discussed horizon. These results show that floristic diversity of plant assemblages from KRAM-P 243/E horizon is much greater than it was assumed earlier.

Dispersed cuticle assemblages from KRAM-P 244/B and KRAM-P 244/C horizons (Tab. 2) are rather poor in species (especially KRAM-P 244/B with only one species) compared to the macroremain assemblages. Similarly as in the case of assemblage from KRAM-P 243/B these differences resulted from the nature of fossil leaf litter from KRAM-P 244/B and KRAM-P 244/C horizons, which consist of mainly twigs of *Glyptostrobus* and plant detritus with only small admixture of remains of leaf blades. Admittedly, in the horizon KRAM-P 244/B only one species of dispersed cuticles (*Dioscoreophyllum liblarense*) was found. However, this species was not found during examination of macroremains and also shows important micromorphological variability. Taxonomic composition of dispersed cuticles assemblage from horizon KRAM-P 244/C confirms presence of genera *Glyptostrobus*, *Byttneriophyllum*, species *Salix hausruckensis* and *Dioscoreophyllum liblarense* (reported earlier as the result of macroremains investigations as cf. *Varipilicutis liblarensis*).

In conclusion it may be said that the assemblages of dispersed cuticles from Ruja are usually considerably less taxonomically diversified than the accumulations of macroremains from the same stratigraphical horizon. However, evidence from dispersed cuticles usually adds data about taxa not found during macroremain analysis. Additionally, there are numerous indeterminate cuticular remains, especially in horizons KRAM-P 243/A and KRAM-P 243/E pointing to the presence of at least several taxa. Thus results of analysis of dispersed cuticles make the Middle Miocene vegetation of Ruja considerably more taxonomically diversified than it could be inferred from leaf macroremain analysis alone.

PALAEOECOLOGY, PALAEOCLIMATE AND AGE OF HORIZONS WITH DISPERSED CUTICLES

As with the macroremains (Worobiec et al. 2008) all dispersed cuticle assemblages are characterized by dominance of floristic elements of wetland vegetation. Only in the KRAM-P 243/E horizon "*Castanea*" *kubinyii* was found, which could be considered as a representative of mesophytic vegetation. The taxonomic composition of dispersed cuticle assemblages suggests that they all originate from wetland vegetation of swamp and riparian forests and also vegetation of water reservoirs. Swamp forests represent the association *Glyptostrobus–Alnus–Byttneriophyllum* (*Acer*, *Alnus*, *Byttneriophyllum*, *Glyptostrobus*, *Myrica*, *Osmunda*, probably *Scheuchzeria*, *Zingiberoideophyllum*). Species of *Salix* and probably *Dombeyopsis* should be considered as riparian forests elements. A presumed representative of family Araceae, *Dioscoreophyllum liblarense*, probably grew on the shore of water reservoirs, probably ox-bow lakes surrounded by reeds (Worobiec et al. 2008). Cuticular remains of the only mesophytic species "*Castanea*" *kubinyii* possibly originated from deciduous broad-leaved forests (Worobiec et al., op. cit).

The dispersed cuticle taxa represent a mainly warm temperate arctotertiary element indicating warm temperate climate conditions during the period of their existence. Plant macroremains of palaeotropical element (*Glyptostrobus*, *Zingiberoideophyllum*) suggest mild winters with absolute minimum temperatures above –5°C. Palaeoclimate of this period could be similar to the recent climate of the Talysh and Colchis areas in Transcaucasia, or the south-eastern part of USA (mean annual temperature +14–16°C, mean temperature of the coolest month +3–5°C, annual precipitation over 1000 mm, comp. Worobiec et al. 2008).

Geology, floristic composition of macroremains assemblages and results of palynological analysis of deposits with plant remains from Ruja pointed to their Middle Miocene (Badenian) age (Worobiec et al. 2008). Data obtained by dispersed cuticles analysis are in accordance with these deductions.

CONCLUSIONS

– As the result of investigation of 526 slides of dispersed cuticles from the Komorniki 97/72 and 97/73 cores, 19 taxa from 13 genera belonging to 11 families of pteridophyta, gymnosperms and angiosperms were identified.

– Two new taxa were described: *Salix semihausruckensis* sp. nov. and *Dicotylophyllum rujense* sp. nov.

– Compared to macroremains from the same stratigraphical horizon, dispersed cuticle assemblages from Ruja are usually considerably less taxonomically diverse. However, results of taxonomic investigations of dispersed cuticles complement data about taxa not found during macroremains analysis.

– Like the macroremain assemblages (Worobiec et al. 2008), all dispersed cuticle assemblages are characterized by dominance of floristic elements of wetland vegetation. Taxonomic composition of dispersed cuticle assemblages suggests existence of *Glyptostrobus-Alnus-Byttneriophyllum* swamp forest community. There are also riparian forests elements (*Salix*, probably *Dombeyopsis*). On the shore of water reservoirs, probably ox-bow lakes surrounded by reeds (Worobiec et al. 2008), *Dioscoreophyllum liblarense* grew. "*Castanea*" *kubinyii* possibly originated from deciduous broad-leaved forests.

– Dispersed cuticle taxa of mainly warm temperate arctotertiary element indicate warm temperate climate conditions, small admixture of palaeotropical element (*Glyptostrobus*, *Zingiberoideophyllum*) suggests mild winters with absolute minimum temperatures above –5°C.

– Geology, floristic composition of macroremains assemblages and results of palynological analysis of deposits with plant remains from Ruja pointed to their Middle Miocene (Badenian) age (Worobiec et al. 2008).

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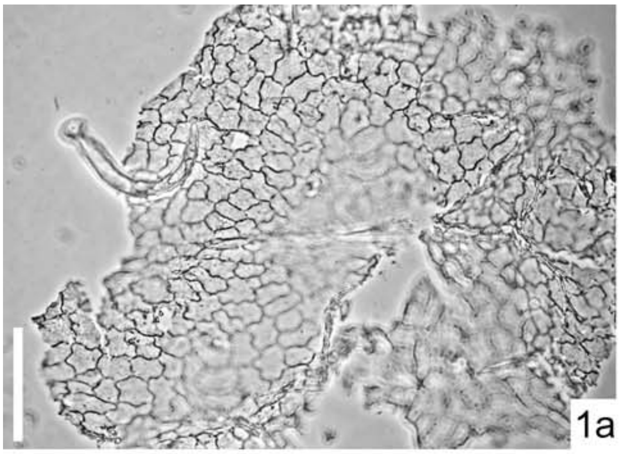
PLATES

Plate 1

Osmunda parschlugiana (Unger) Andreánszky

1a. Adaxial epidermis, specimen No. KRAM-P 243/E/CDisp/193
1b. Enlargement of adaxial epidermis, specimen No. KRAM-P 243/E/CDisp/193
2a. Abaxial epidermis, with stomata and trichomes, specimen No. KRAM-P 243/A/CDisp/34
2b. Detail of abaxial epidermis. Note the anomocytic stomata and strongly undulate cell walls, specimen No. KRAM-P 243/A/CDisp/34
2c. Detail of stoma structure, specimen No. KRAM-P 243/A/CDisp/34
2d. Detail of margin venation of leaflet, specimen No. KRAM-P 243/A/CDisp/34
3a. Trichomes near vein on abaxial epidermis, specimen No. KRAM-P 243/A/CDisp/33
3b. Detail of trichomes, specimen No. KRAM-P 243/A/CDisp/33

1a, 2a, b, d, 3a: scale bar – 100 µm; 1b, 2c, 3b: scale bar – 50 µm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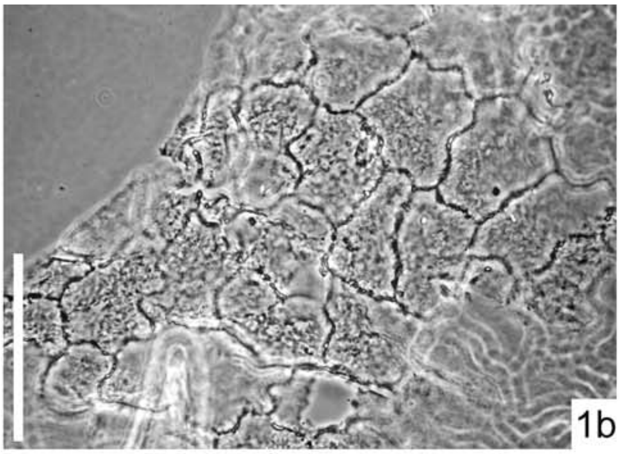
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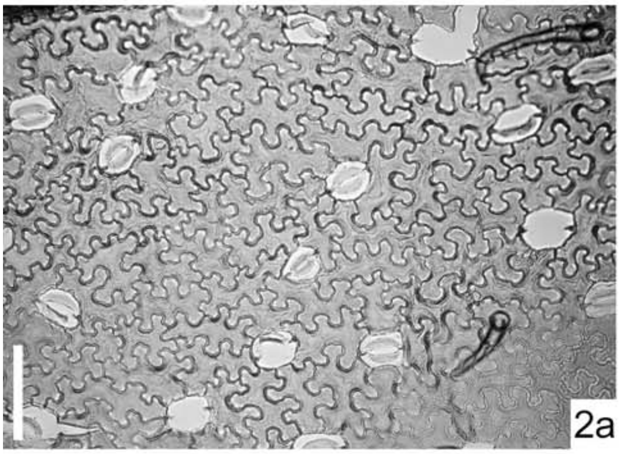
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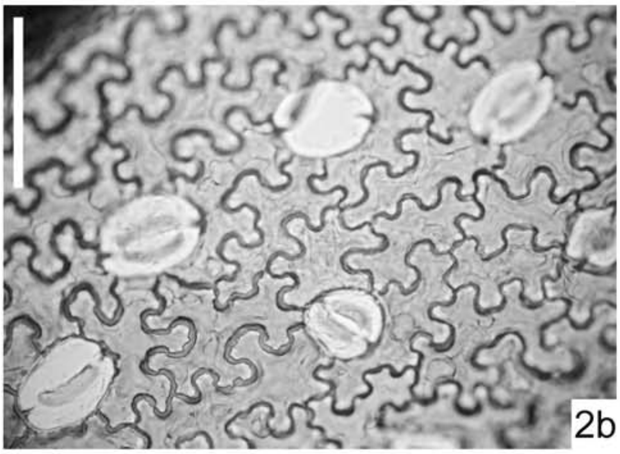
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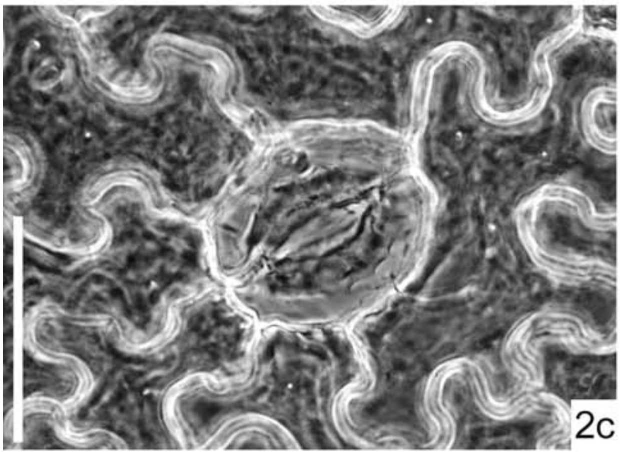
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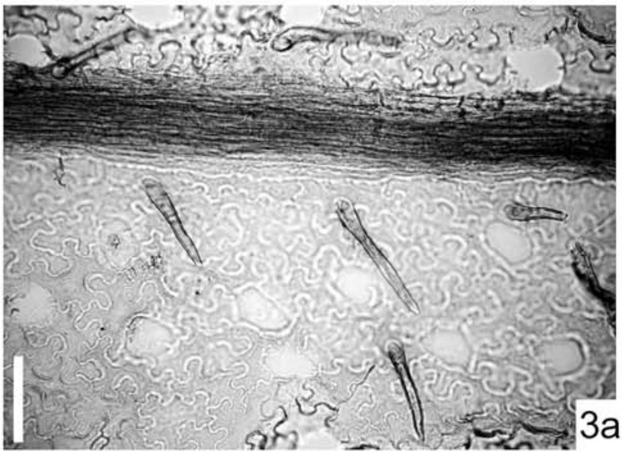
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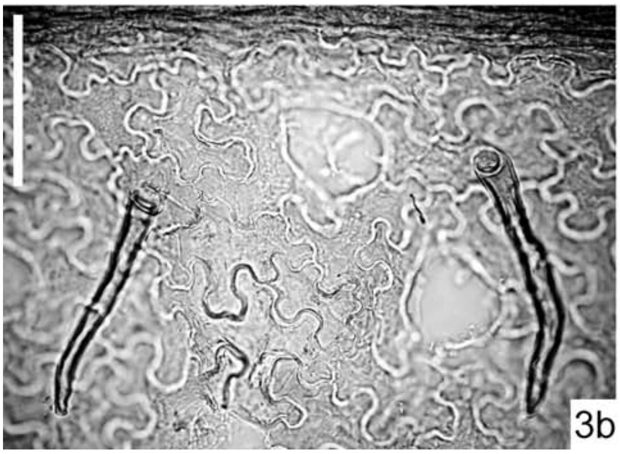
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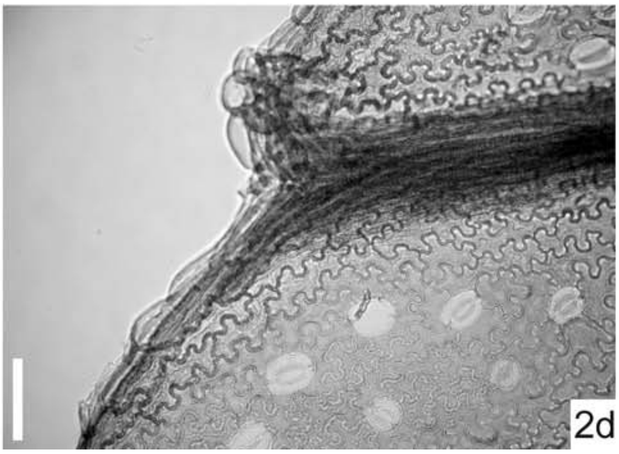
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Plate 2

Glyptostrobus europaeus (Brongniart) Unger

1. Epidermis. Note the considerably short epidermal cells, specimen No. KRAM-P 243/E/CDisp/161
2a. Epidermal cells with granular cuticle (possibly remnants of epicuticular wax), specimen No. KRAM-P 243/E/CDisp/164
2b. Detail of stomata, specimen No. KRAM-P 243/E/CDisp/164
3. Fragment of stomatal band, specimen No. KRAM-P 243/E/CDisp/158

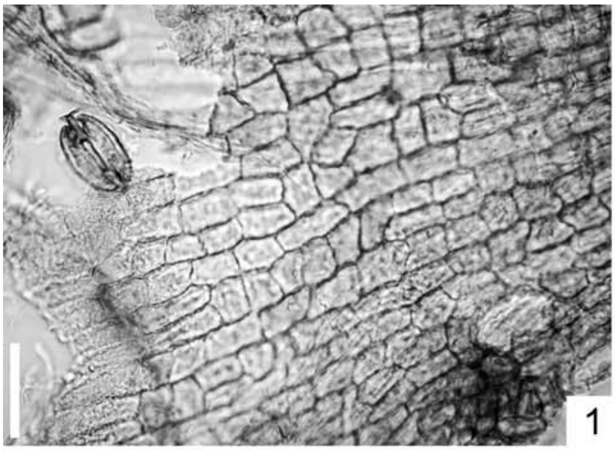
Acer sp.

4. Adaxial epidermis. Note the striae ornamentation of cuticle, specimen No. KRAM-P 243/E/CDisp/111
5. Abaxial epidermis with stomata, specimen No. KRAM-P 243/E/CDisp/181

Alnus julianiformis (Sternberg) Z. Kvaček & Holý

6a. Adaxial epidermis with stoma, specimen No. 243/B/CDisp/15
6b. Detail of adaxial epidermis, specimen No. 243/B/CDisp/15

1, 2a, b, 4, 5, 6b: scale bar – 50 µm; 3, 6a: scale bar – 100 µm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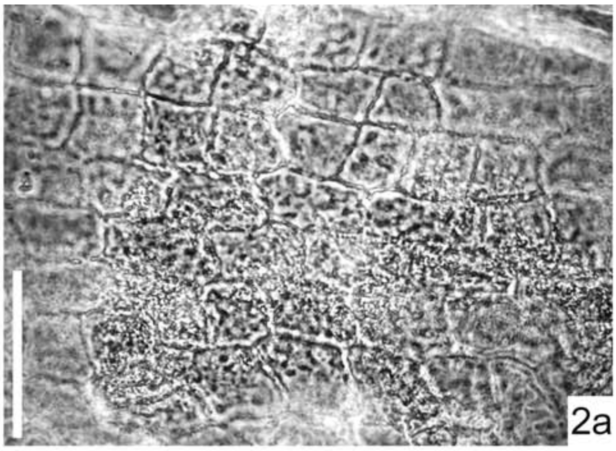
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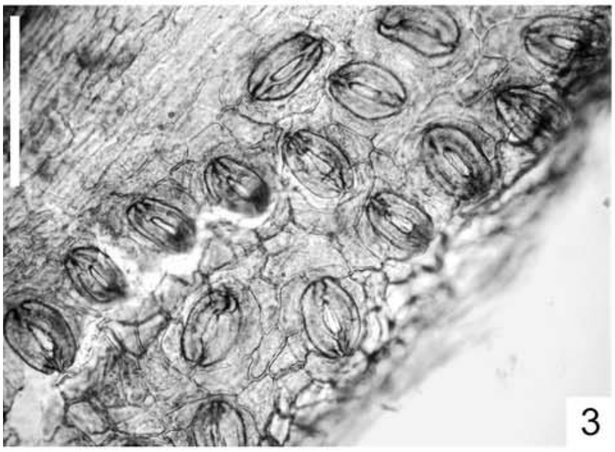
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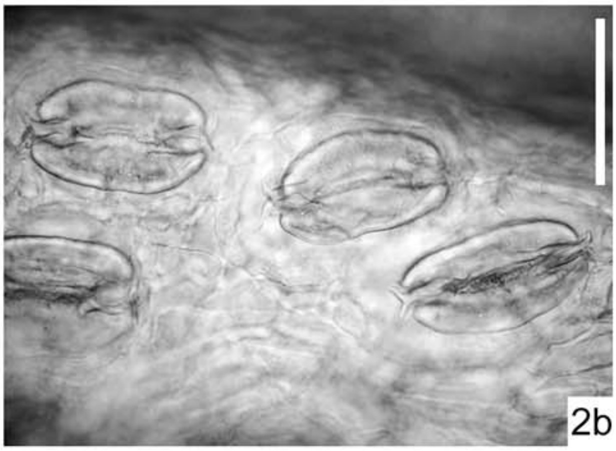
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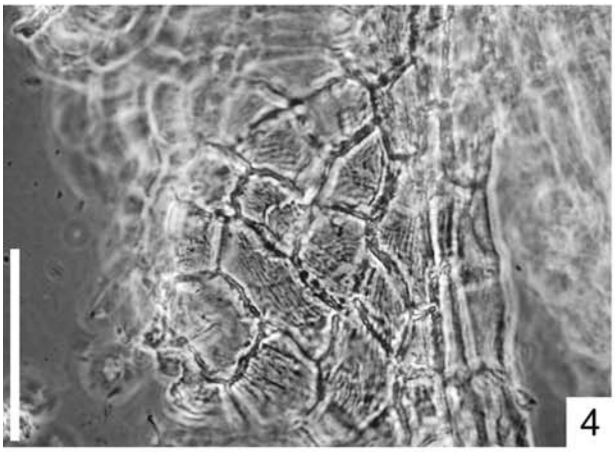
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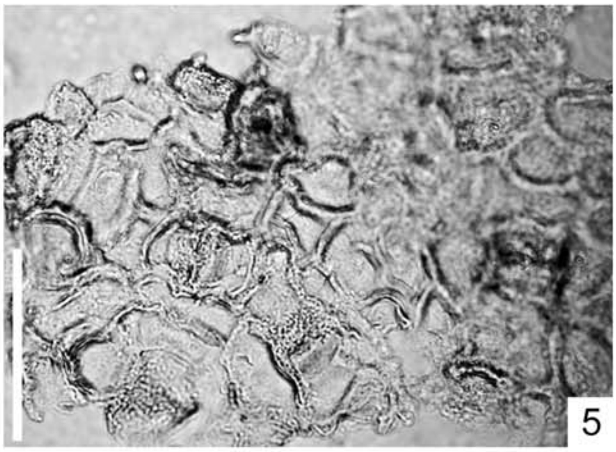
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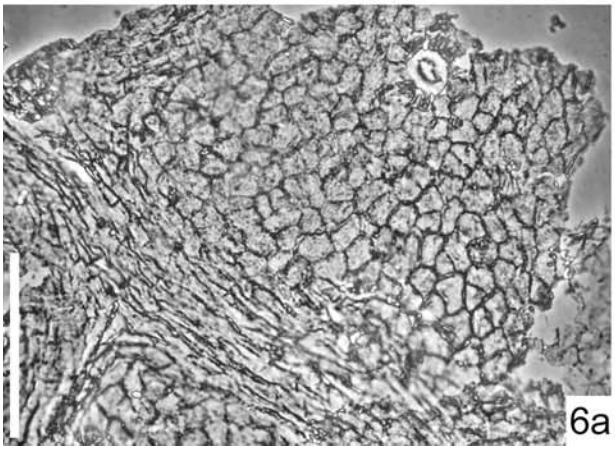
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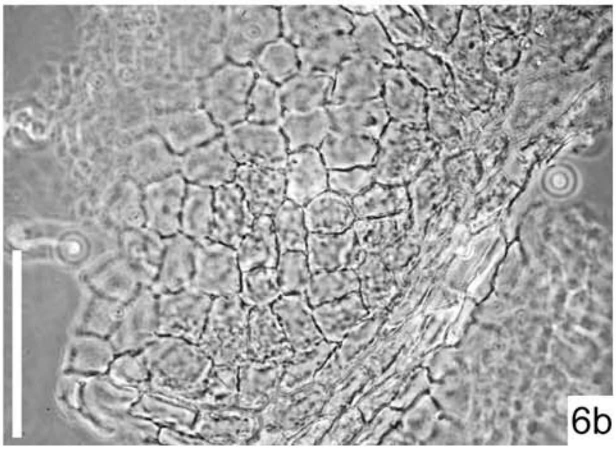
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Plate 3

Alnus julianiformis (Sternberg) Z. Kvaček & Holý

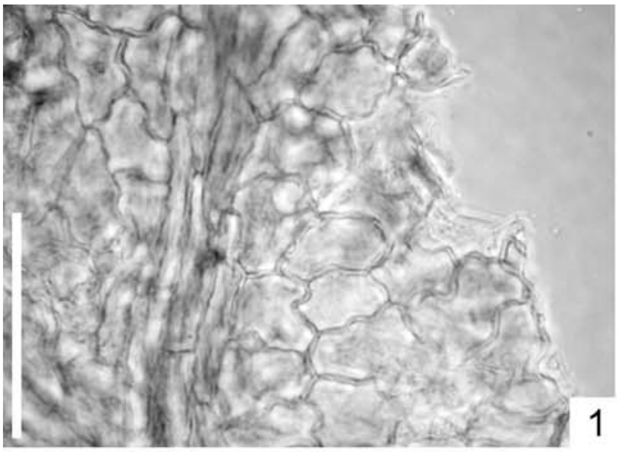
1. Abaxial epidermis. Note the undulate cell walls, specimen No. KRAM-P 243/E/CDisp/86
2. Abaxial epidermis with stoma, specimen No. KRAM-P 243/E/CDisp/104
3. Detail of stoma structure, specimen No. KRAM-P 243/B/CDisp/15
4. Four-celled base of glandular trichome on abaxial epidermis, specimen No. KRAM-P 243/E/CDisp/82
5. Peltate glandular trichome. Note the four-celled base, specimen No. KRAM-P 243/E/CDisp/98
6. Solitary trichome (possibly element of domatium), specimen No. KRAM-P 243/E/CDisp/107

Alnus menzelii Raniecka-Bobrowska

7a. Adaxial epidermis, specimen No. KRAM-P 243/B/CDisp/13
7b. Detail of adaxial epidermis showing cuticular striations, specimen No. KRAM-P 243/B/CDisp/13

1, 5, 6, 7a, b: scale bar – 50 µm; 2, 3, 4: scale bar – 25 µm

Plate 3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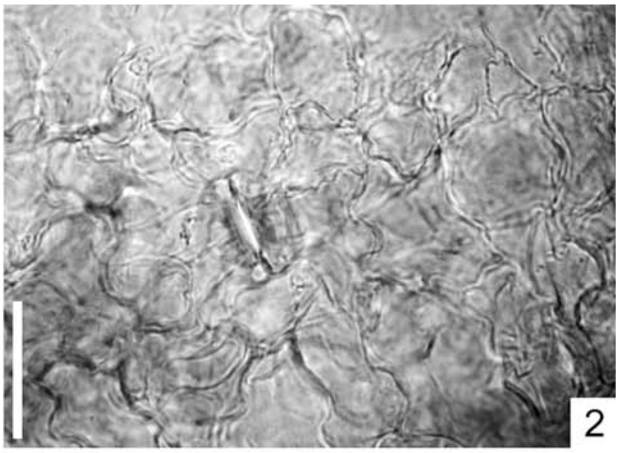
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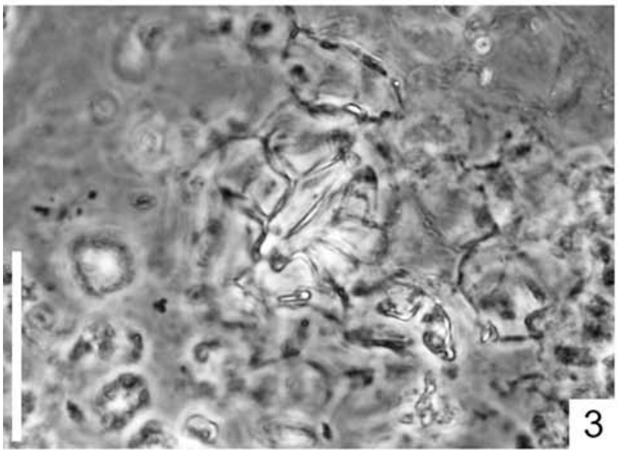
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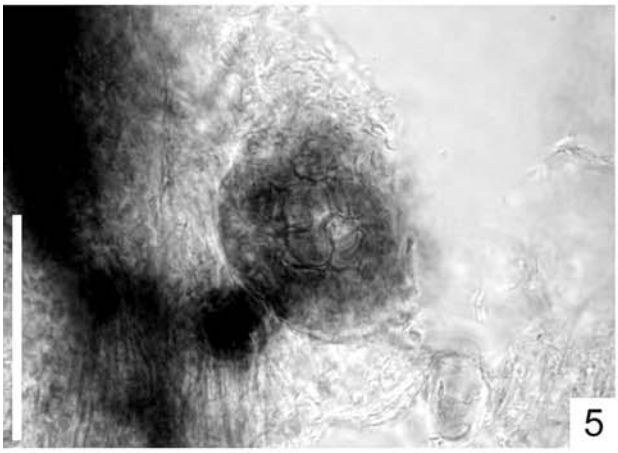
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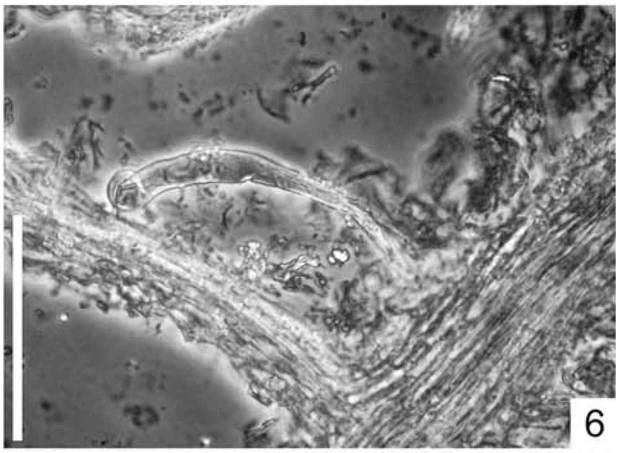
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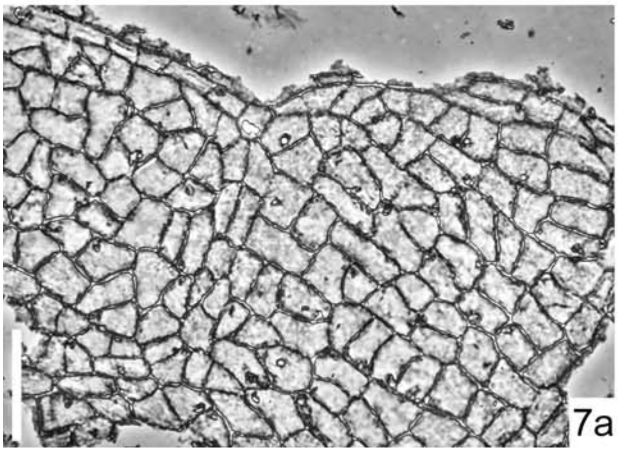
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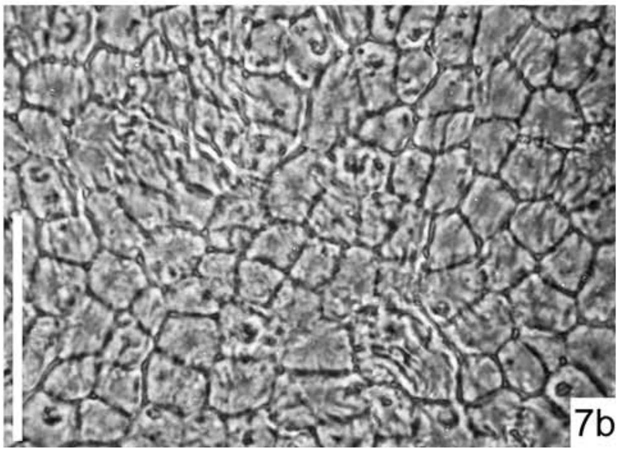

7b

Plate 4

Alnus menzelii Raniecka-Bobrowska

1a. Abaxial epidermis with stomata and four-celled base of glandular trichome, specimen No. KRAM-P 243/B/CDisp/13
1b. Detail of four-celled base of glandular trichome, specimen No. KRAM-P 243/B/CDisp/13

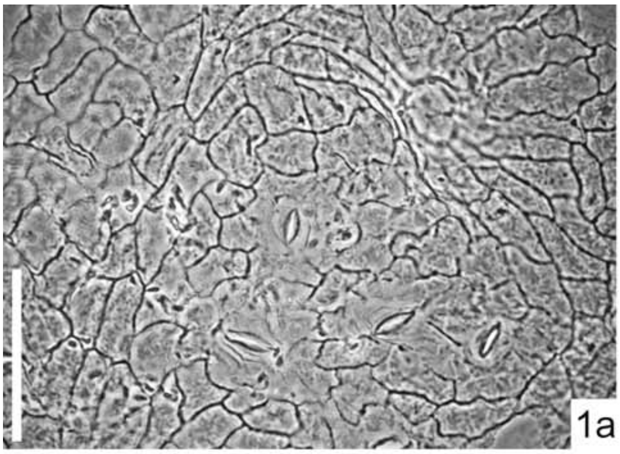
Byttneriophyllum tiliifolium (Al. Braun) Knobloch & Z. Kvaček

2. Detail of margin venation of leaf, specimen No. KRAM-P 243/A/CDisp/119
3. Adaxial epidermis, specimen No. KRAM-P 244/C/CDisp/12

4a. Detail of adaxial epidermis, specimen No. KRAM-P 244/C/CDisp/13
4b. Abaxial epidermis with stomata. Note the dense cover of stellate trichomes, specimen No. KRAM-P 244/C/CDisp/13
4c. Detail of abaxial epidermis, specimen No. KRAM-P 244/C/CDisp/13

5. Adaxial epidermis. Note the cuticular ornamentation (reticulum), specimen No. KRAM-P 243/A/CDisp/115

1a, 4c: scale bar – 50 µm; 1b, 4a, 5: scale bar – 25 µm; 2, 3, 4b: scale bar – 100 µm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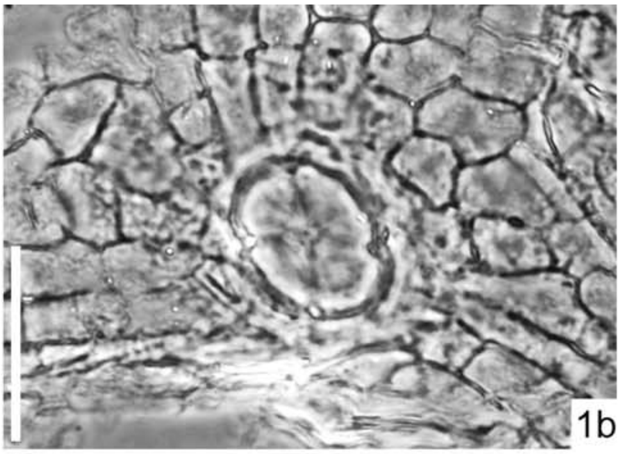
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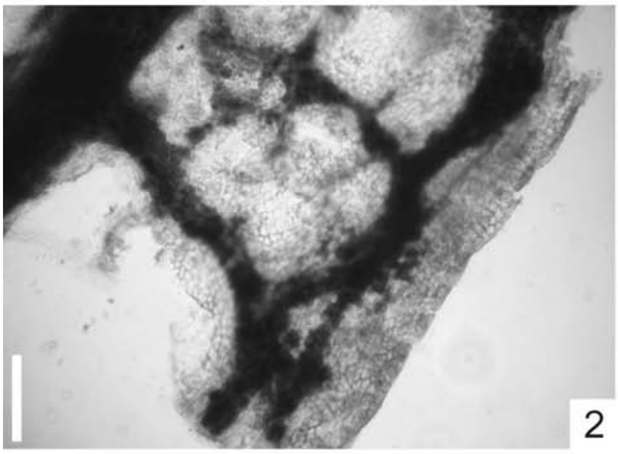
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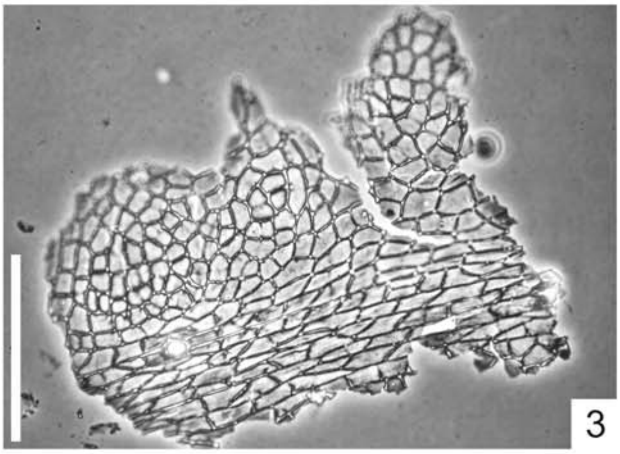
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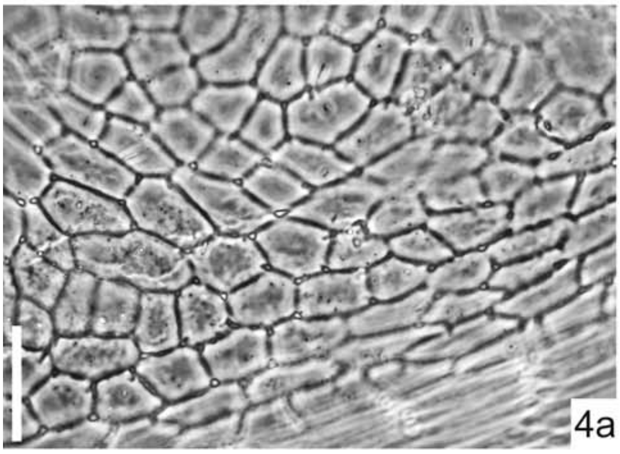
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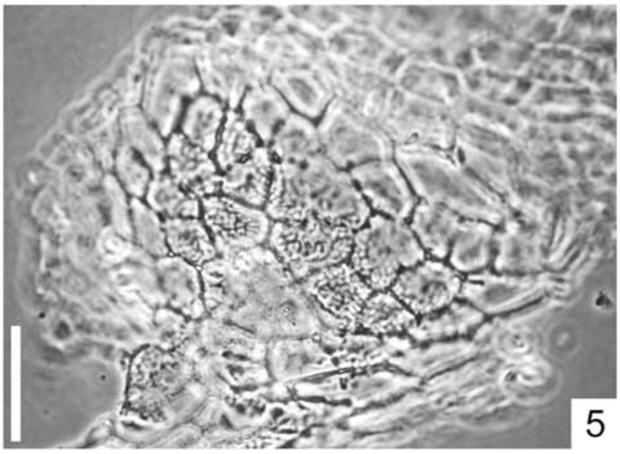
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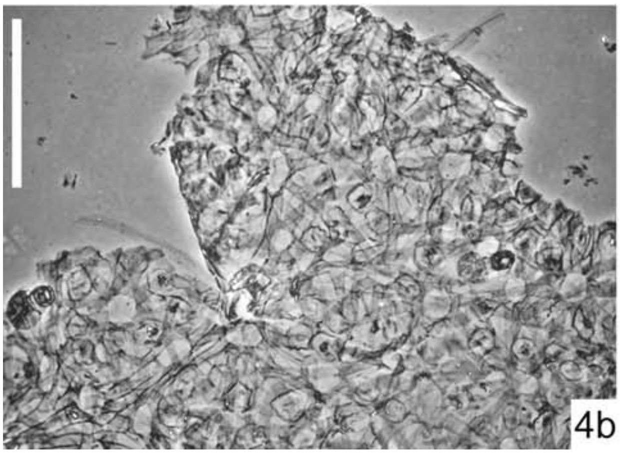
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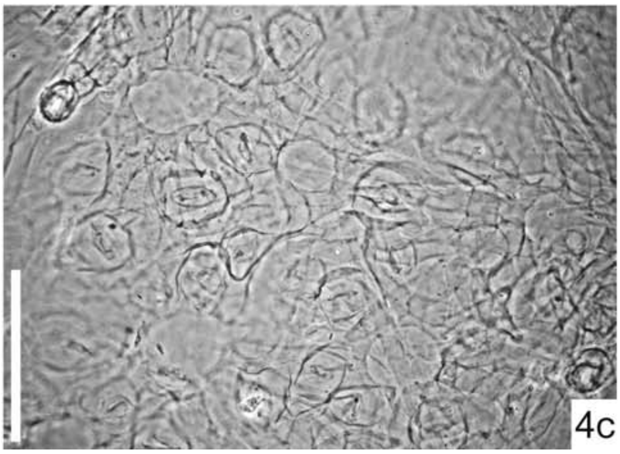

4c

Plate 5

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

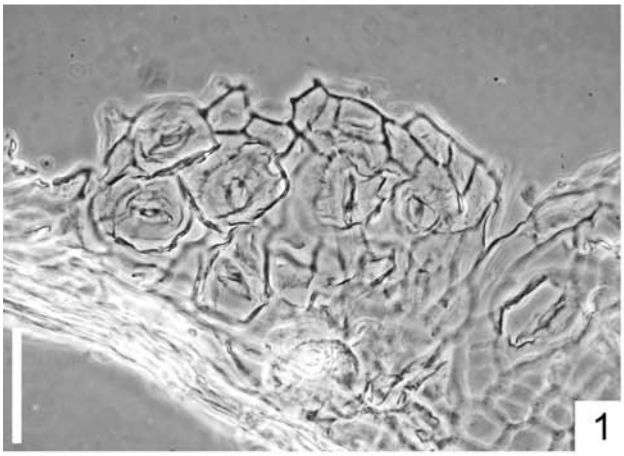
1. Abaxial epidermis with stomata, specimen No. KRAM-P 243/A/CDisp/120
2. Detail of stellate trichome, specimen No. KRAM-P 243/A/CDisp/110

3a. Detail of stellate trichome, specimen No. KRAM-P 244/C/CDisp/12
3b. Stellate trichome (A) and glandular clavate trichomes (B), specimen No. KRAM-P 244/C/CDisp/12
3c. Detail of glandular clavate trichome, specimen No. KRAM-P 244/C/CDisp/12
3d. Detail of glandular clavate trichome, specimen No. KRAM-P 244/C/CDisp/12

cf. *Dombeyopsis lobata* Unger

4a. Detail of stellate trichome, specimen No. KRAM-P 243/A/CDisp/220
4b. Detail of stellate trichome, specimen No. KRAM-P 243/A/CDisp/220

1, 3c, d: scale bar – 25 µm; 2, 3a, b, 4a, b: scale bar – 50 µm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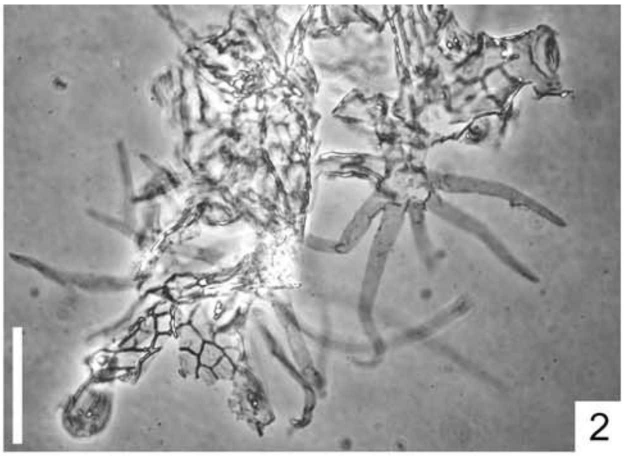
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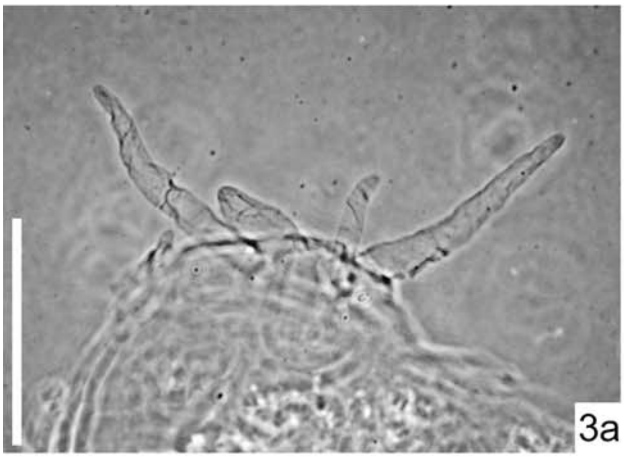
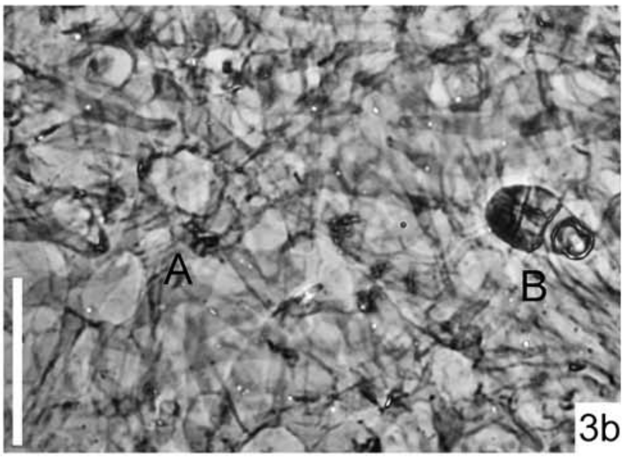
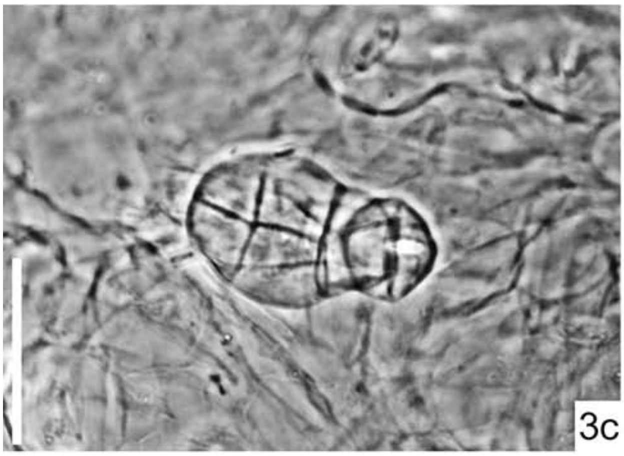

3a


A
B
3b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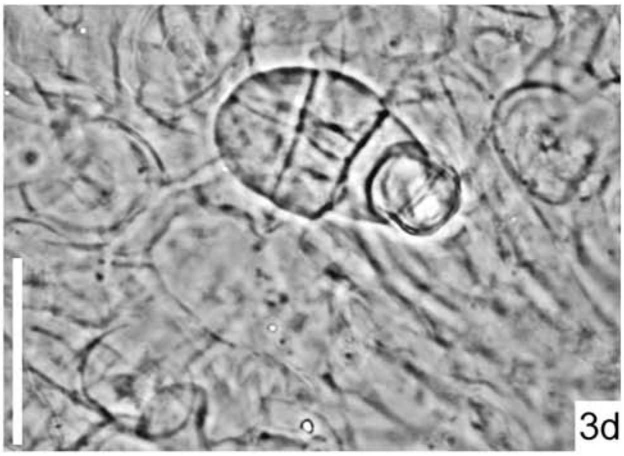
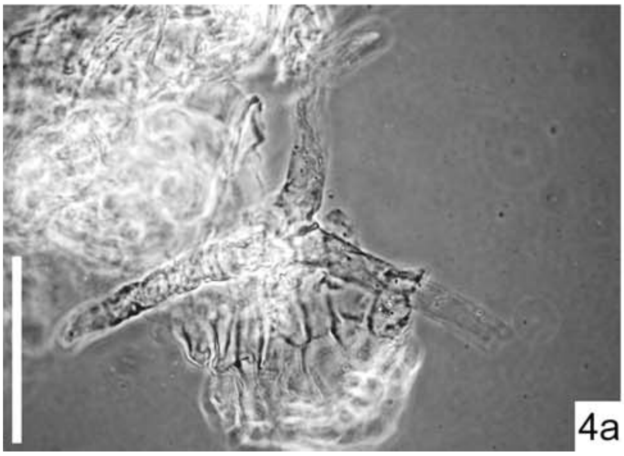

3d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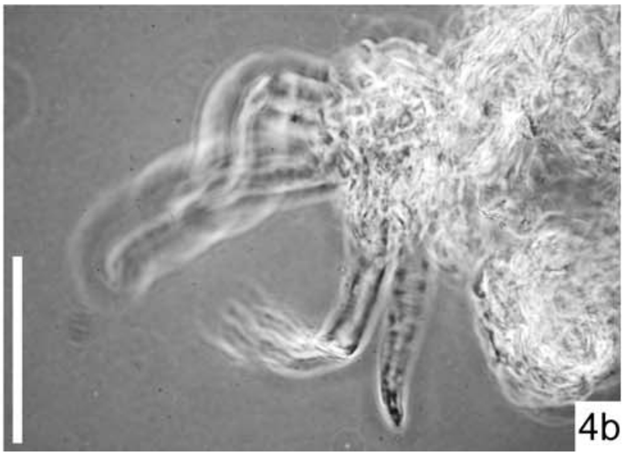
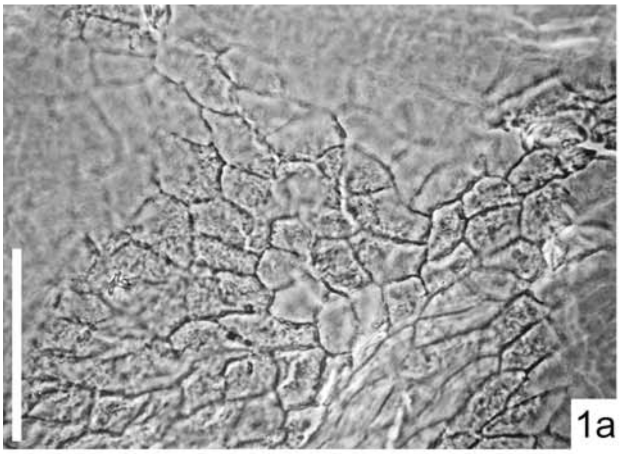

4b

Plate 6

Myrica lignitum (Unger) Saporta *sensu lato*

1a. Adaxial epidermis, specimen No. KRAM-P 243/A/CDisp/184
1b. Detail of adaxial epidermis. Note the visible two-layered hypodermis, specimen No. KRAM-P 243/A/CDisp/184
1c. Abaxial epidermis with stomata, specimen No. KRAM-P 243/A/CDisp/184
1d. Peltate trichome shields over veins, specimen No. KRAM-P 243/A/CDisp/184
1e. Peltate trichome shield, specimen No. KRAM-P 243/A/CDisp/184
1f. Radial cellular structure of peltate trichome shield, specimen No. KRAM-P 243/A/CDisp/184
1g. Two-celled base of peltate glandular trichome, specimen No. KRAM-P 243/A/CDisp/184
2. Two-celled base of peltate glandular trichome, specimen No. KRAM-P 243/A/CDisp/185

1a–f: scale bar – 50 μm; 1g, 2: scale bar – 25 μm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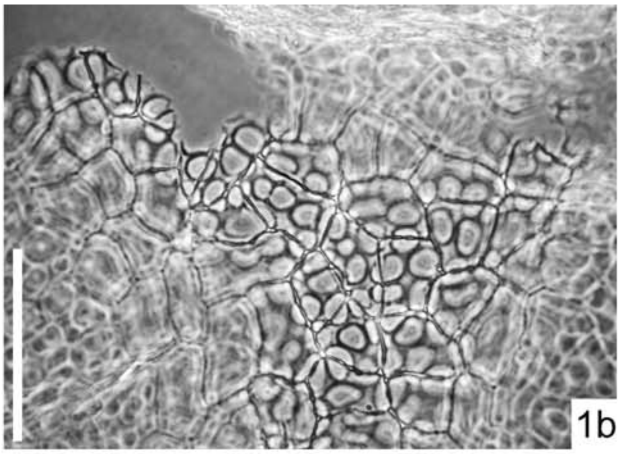
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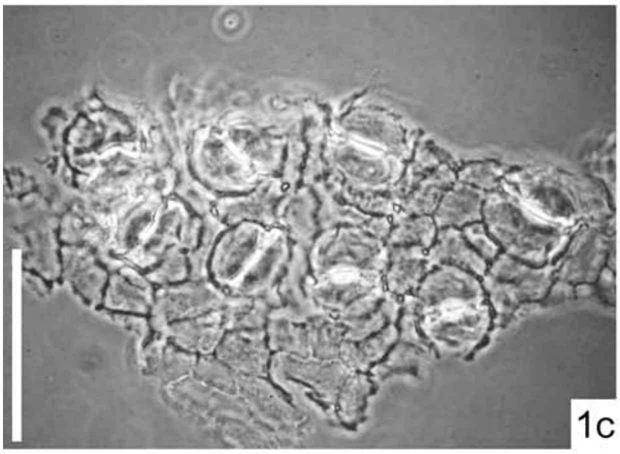
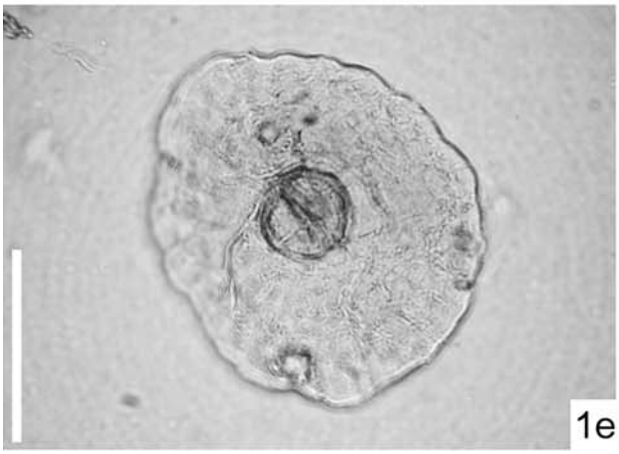

1c


1d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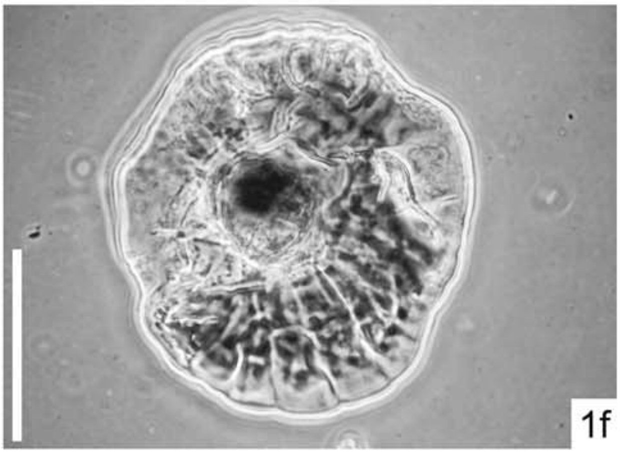
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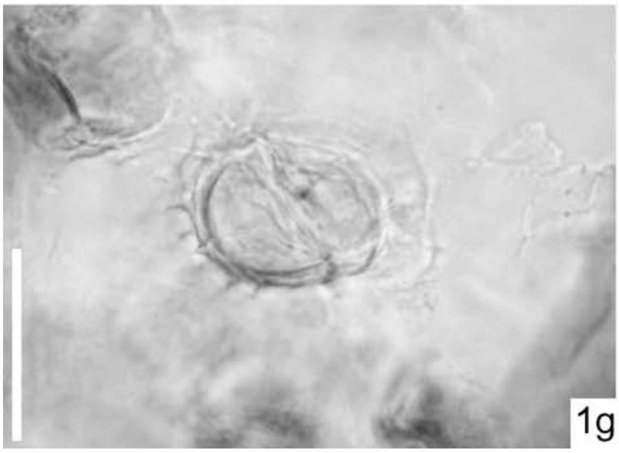
1g

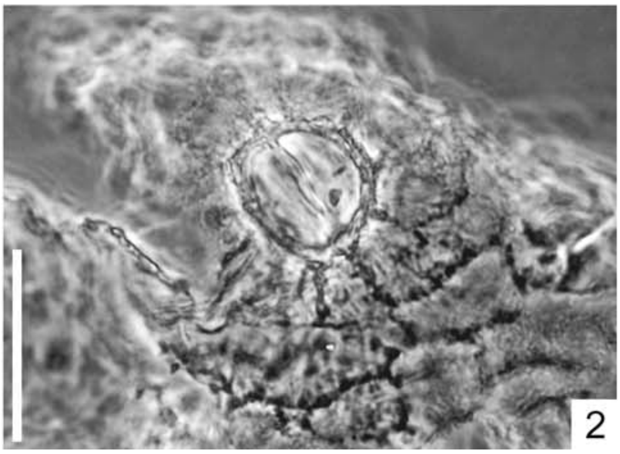
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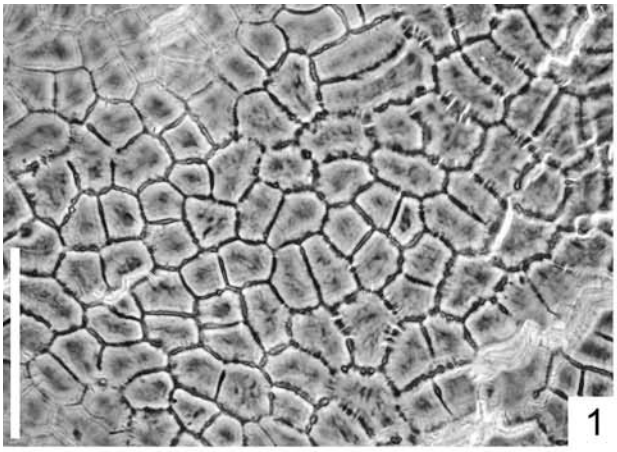
Plate 7

Salix hausruckensis Kovar-Eder

1. Adaxial epidermis, specimen No. KRAM-P 243/A/CDisp/50
2a. Adaxial epidermis. Note the cuticular striations, specimen No. KRAM-P 243/E/CDisp/241
2b. Abaxial epidermis. Note the various types of stomata and dense cover of epicuticular wax, specimen No. KRAM-P 243/E/CDisp/241
3. Abaxial epidermis. Note the various types of stomata and cover of epicuticular wax, specimen No. KRAM-P 243/A/CDisp/51
4a. Abaxial epidermis. Note the various types of stomata and lack of distinct cover of epicuticular wax, specimen No. KRAM-P 243/A/CDisp/62
4b. Abaxial epidermis. Note the various types of stomata, specimen No. KRAM-P 243/A/CDisp/62
5a. Abaxial epidermis. Note the stomata and unicellular trichome bases, specimen No. KRAM-P 243/B/CDisp/16
5b. Abaxial epidermis. Note the numerous unicellular trichome bases over veins, specimen No. KRAM-P 243/B/CDisp/16

scale bar – 50 µm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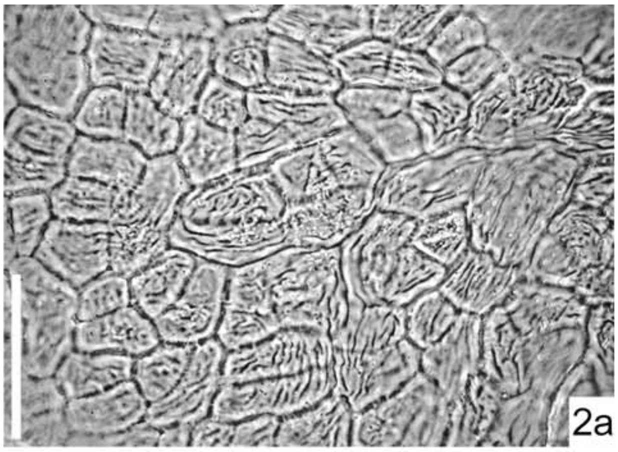
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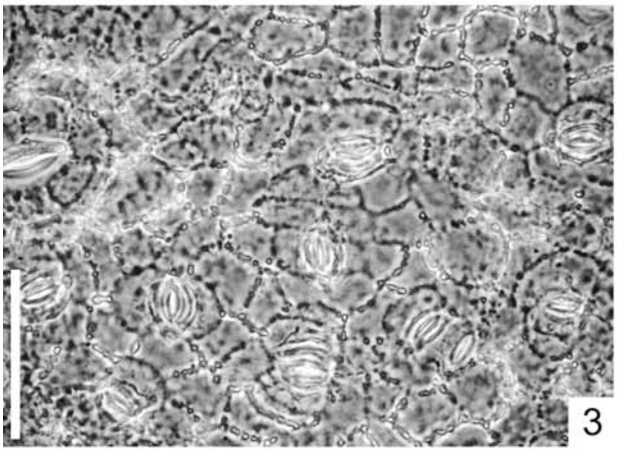
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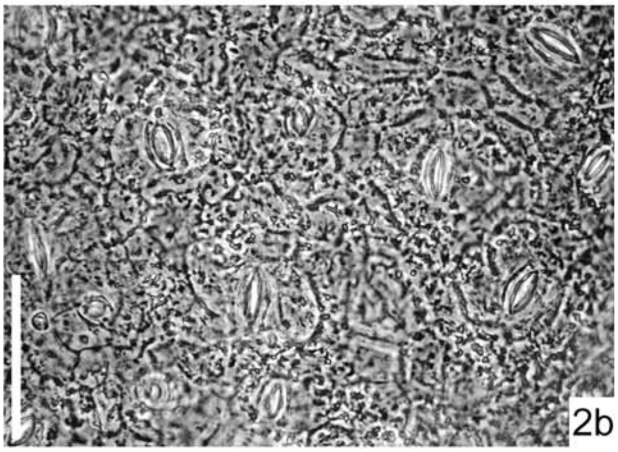
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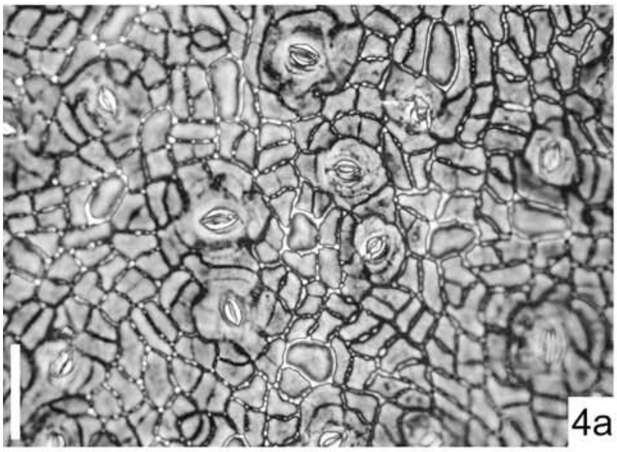
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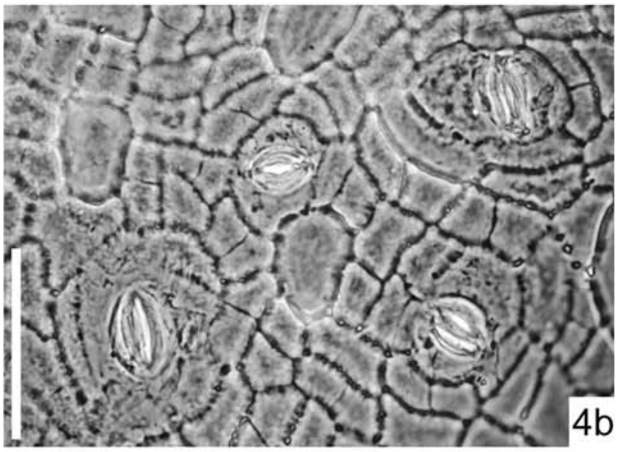
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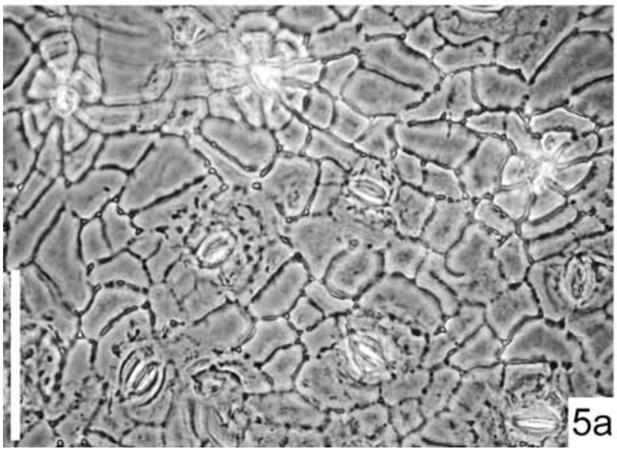
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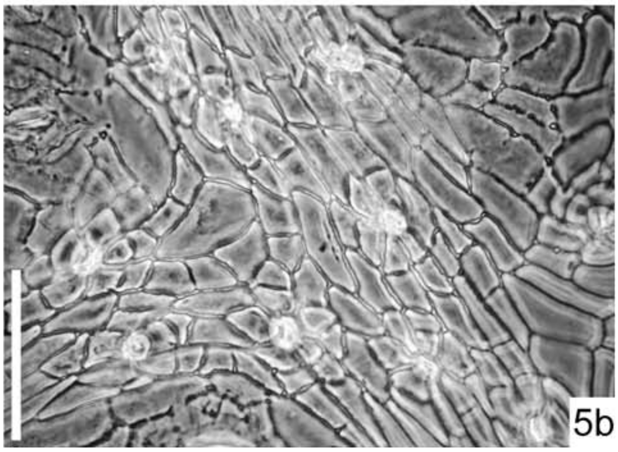

5b

Plate 8

Salix semihausruckensis sp. nov.

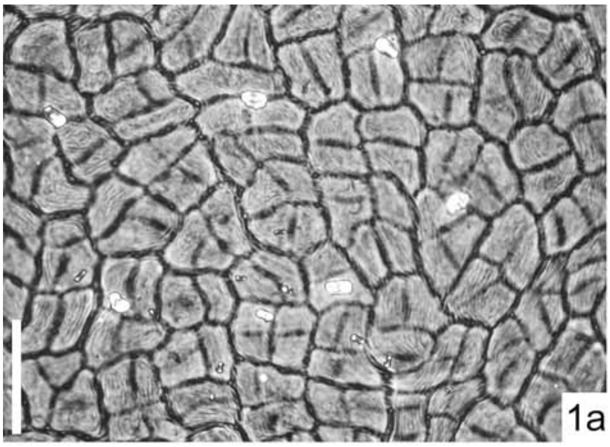
1a. Adaxial epidermis. Note the cuticular striations, holotype, specimen No. KRAM-P 243/A/CDisp/198
1b. Detail of adaxial epidermis showing cuticular striations, holotype, specimen No. KRAM-P 243/A/CDisp/198
2a. Adaxial epidermis. Note the cuticular striations, paratype, specimen No. KRAM-P 243/A/CDisp/196
2b. Detail of adaxial epidermis showing cuticular striations, paratype, specimen No. KRAM-P 243/A/CDisp/196
3a. Abaxial epidermis. Note the various types of stomata, specimen No. KRAM-P 243/A/CDisp/197
3b. Abaxial epidermis. Note the various types of stomata, specimen No. KRAM-P 243/A/CDisp/197

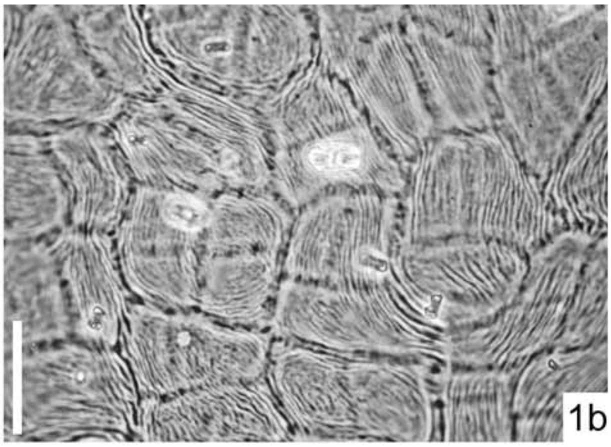
Salix varians Goeppert *sensu lato*
morphotype A

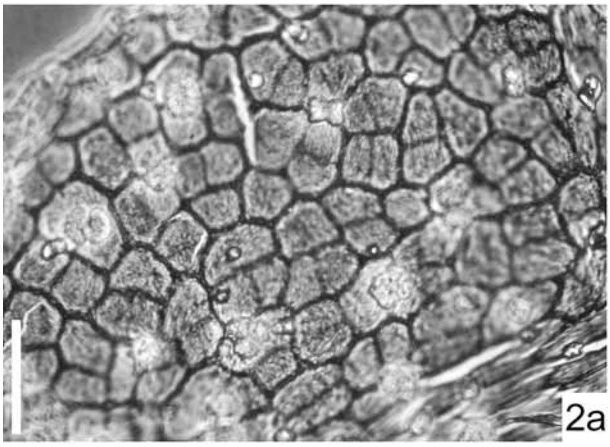
4. Adaxial epidermis, specimen No. KRAM-P 243/A/CDisp/80
5. Brachyparacytic stoma, specimen No. KRAM-P 243/A/CDisp/84

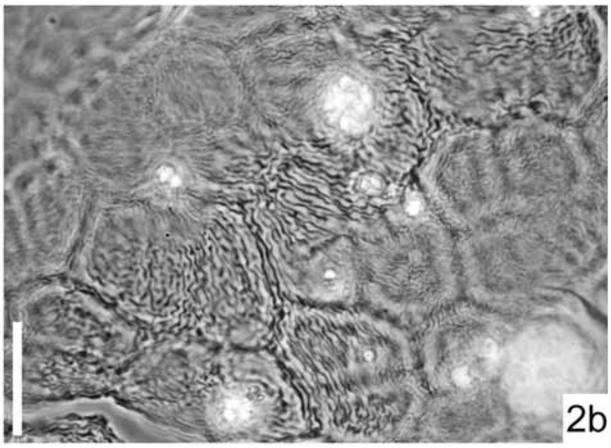
1a, 2a, 3b, 4: scale bar – 50 µm; 1b, 2b, 5: scale bar – 25 µm; 3a: scale bar – 100 µm

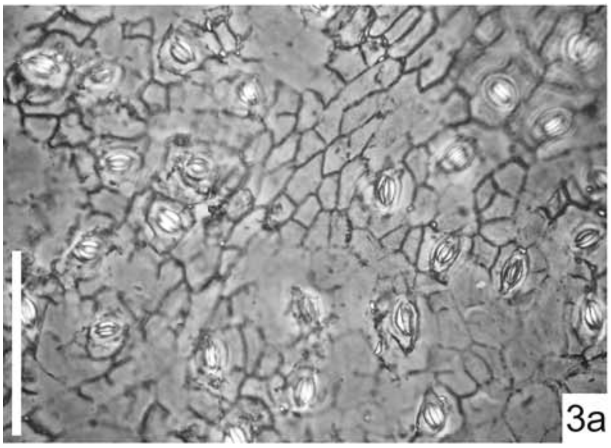
Plate 8

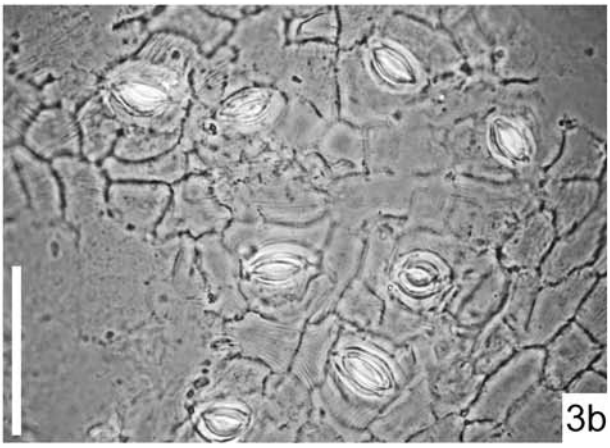


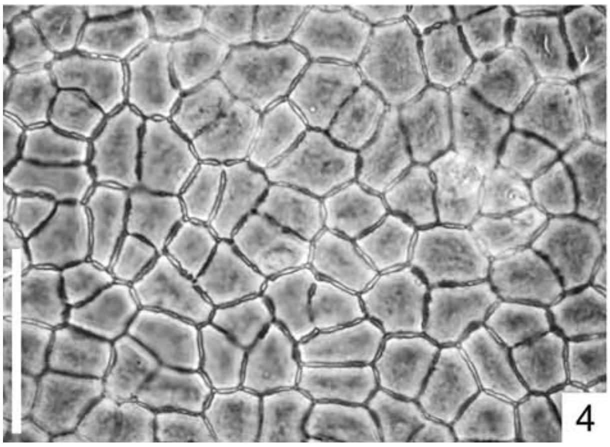












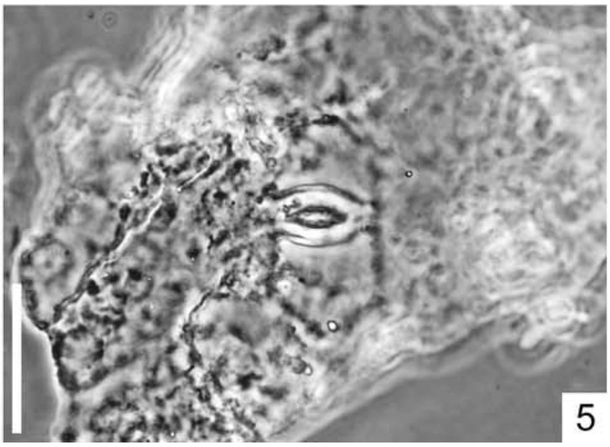


Plate 9

Salix varians Goeppert *sensu lato*
morphotype B

1. Adaxial epidermis, specimen No. KRAM-P 243/A/CDisp/168
2. Abaxial epidermis with stomata, specimen No. KRAM-P 243/A/CDisp/106

3a. Detail of abaxial epidermis showing structure of epicuticular wax layer (phase contrast), specimen No. KRAM-P 243/A/CDisp/169

3b. Detail of abaxial epidermis showing structure of epicuticular wax layer (dark field), specimen No. KRAM-P 243/A/CDisp/169

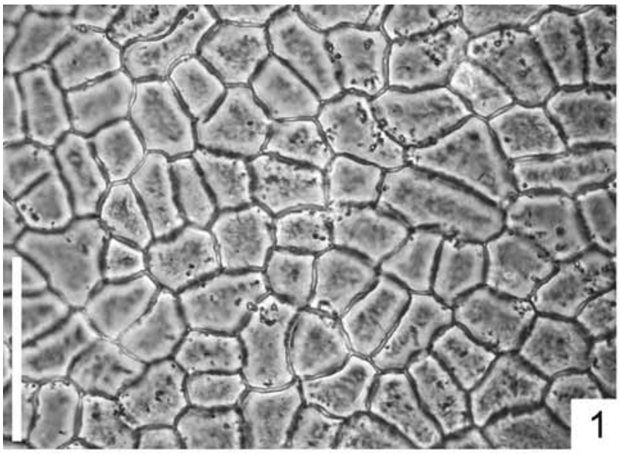
“*Castanea*” *kubinyii* Kováts ex Ettingshausen sensu Knobloch & Z. Kvaček

4a. Adaxial epidermis, specimen No. KRAM-P 243/E/CDisp/46

4b. Adaxial epidermis, specimen No. KRAM-P 243/E/CDisp/46

5. Abaxial epidermis with stomata, specimen No. KRAM-P 243/E/CDisp/30
6. Abaxial epidermis with stomata, specimen No. KRAM-P 243/E/CDisp/54

1, 2, 3a, b, 5: scale bar – 50 µm; 4a, b, 6: scale bar – 25 µm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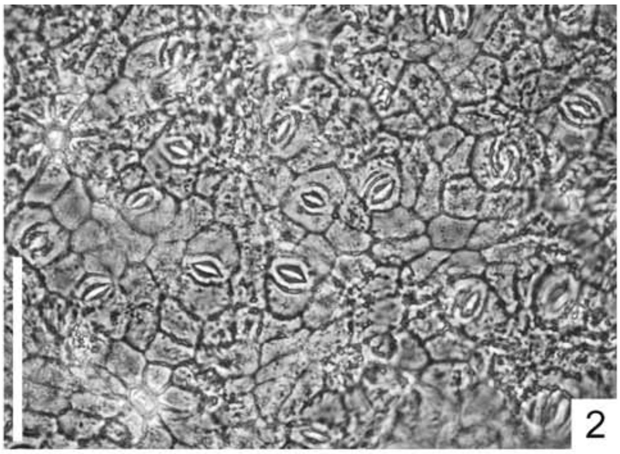
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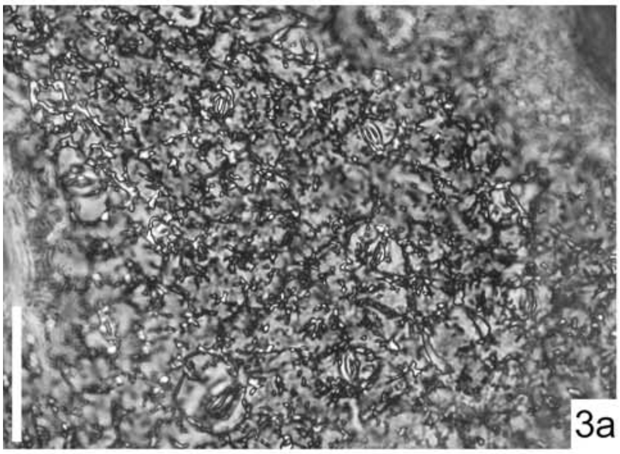
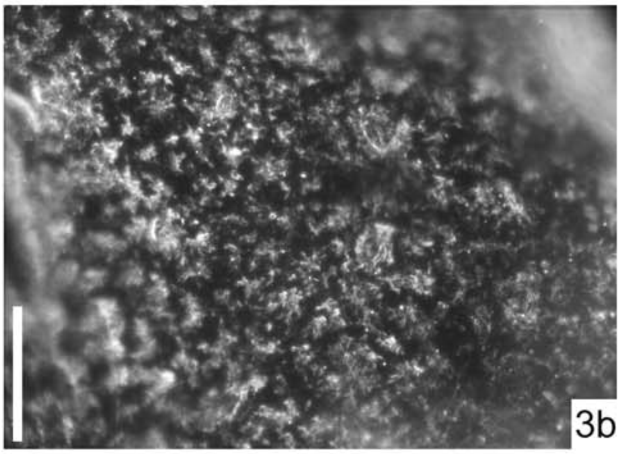

3a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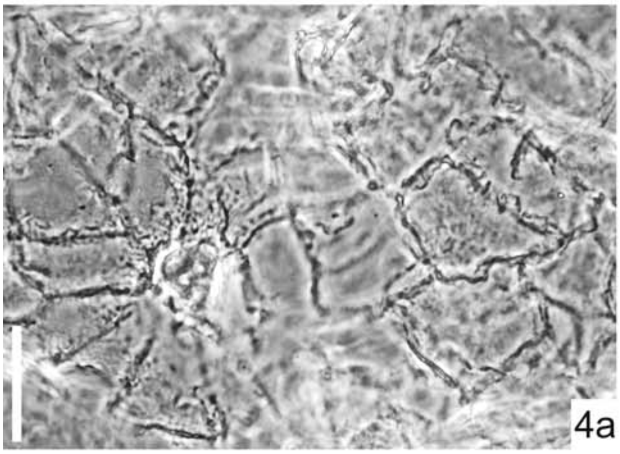
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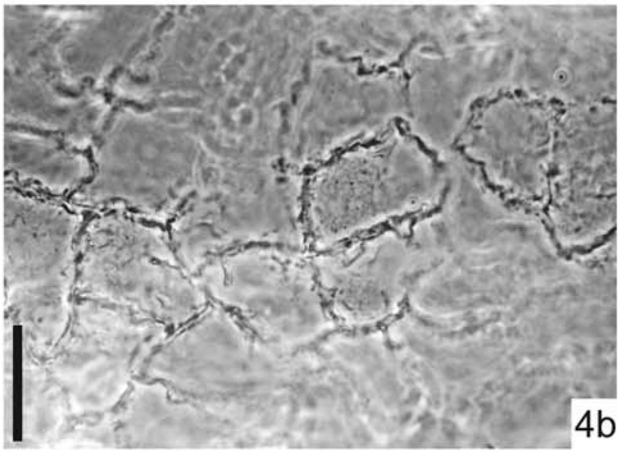
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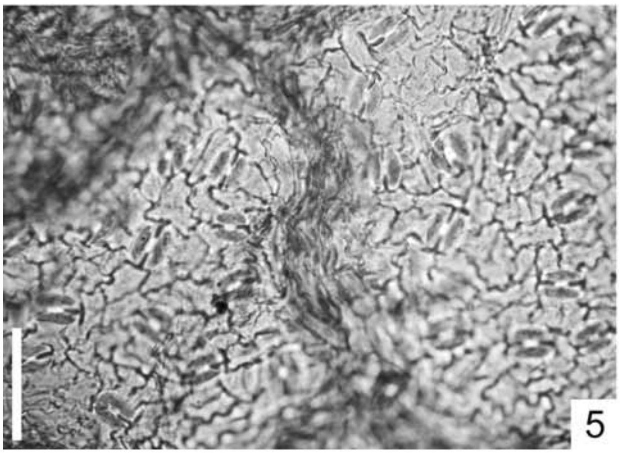
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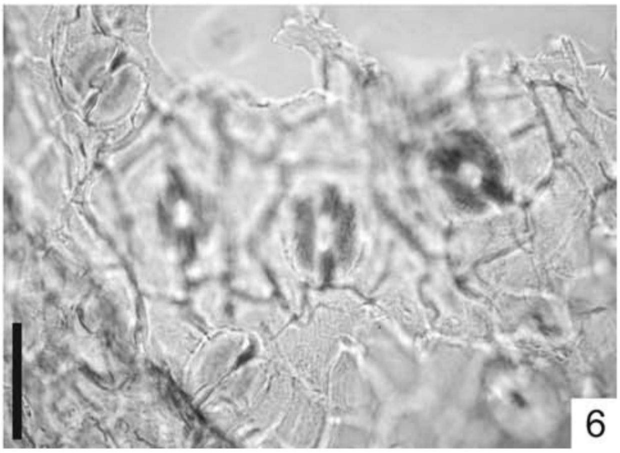
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Plate 10

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

1a. Trichomes on abaxial epidermis, specimen No. KRAM-P 243/E/CDisp/54
1b. Detail of trichome, specimen No. KRAM-P 243/E/CDisp/54

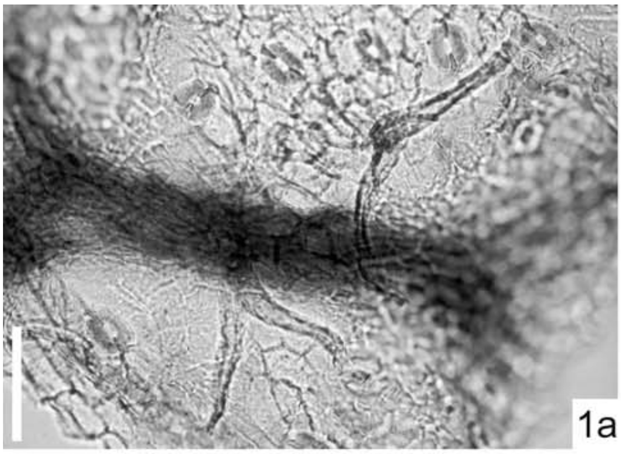
Dicotylophyllum rujense sp. nov.

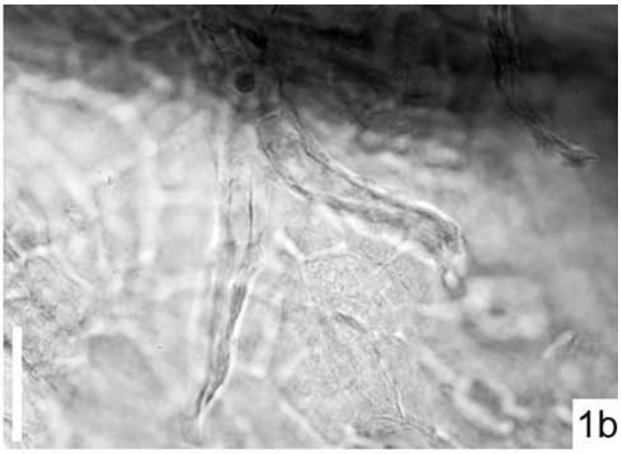
2a. Adaxial epidermis. Note the cuticular striations, paratype, specimen No. KRAM-P 243/B/CDisp/10
2b. Detail of adaxial epidermis showing cuticular striations, paratype, specimen No. KRAM-P 243/B/CDisp/10
3a. Abaxial epidermis with stomata, holotype, specimen No. KRAM-P 243/B/CDisp/5
3b. Abaxial epidermis with stomata, holotype, specimen No. KRAM-P 243/B/CDisp/5

Dicotylophyllum sp. 1

4a. Adaxial epidermis, specimen No. KRAM-P 243/A/CDisp/206
4b. Abaxial epidermis with stomata, specimen No. KRAM-P 243/A/CDisp/206

1a, 2a, b, 3a, b, 4a: scale bar – 50 µm; 1b, 4b: scale bar – 25 µm


1a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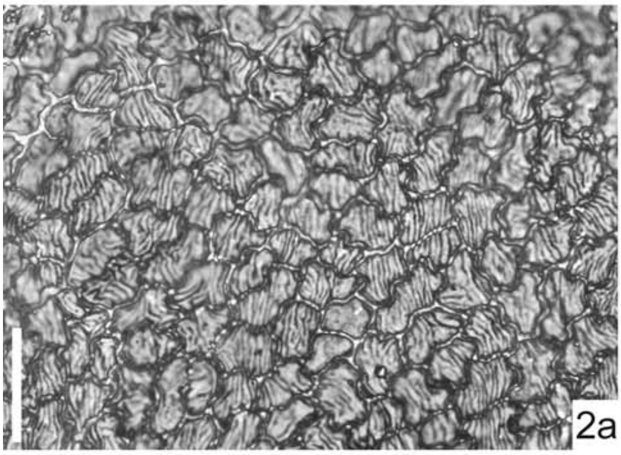
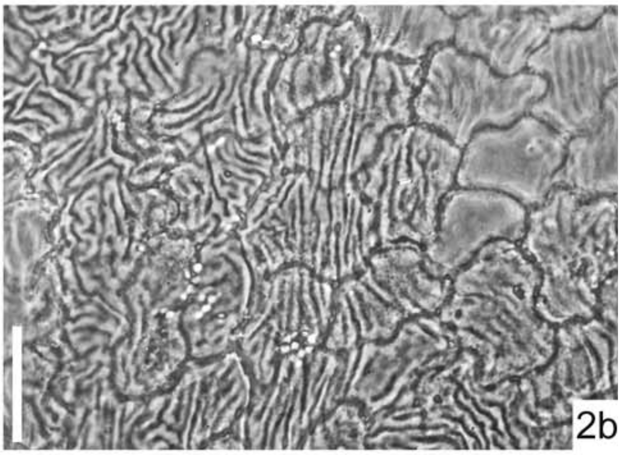

2a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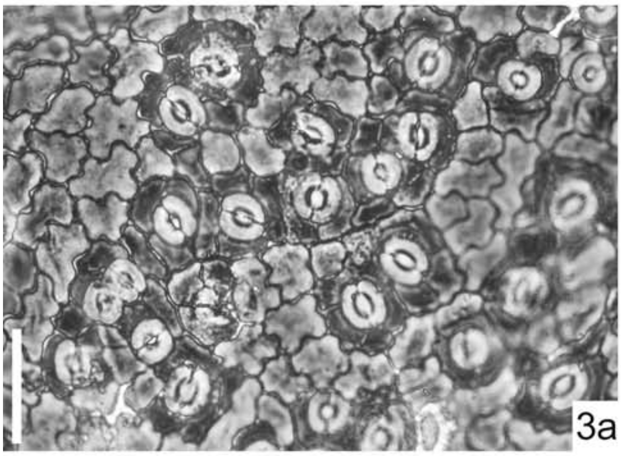
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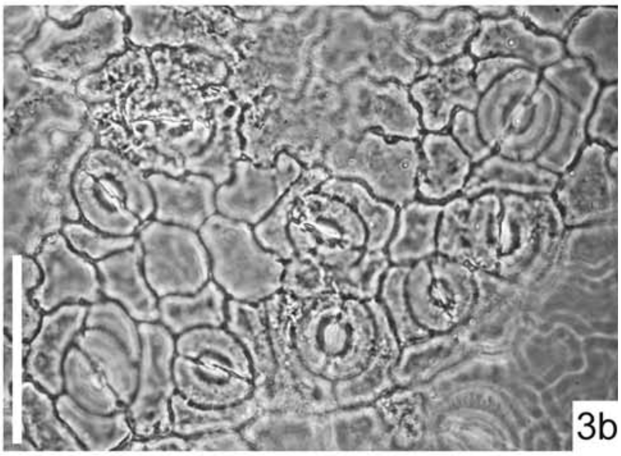
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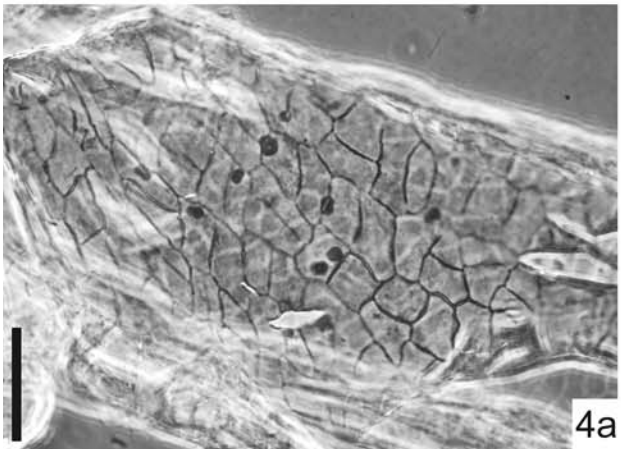
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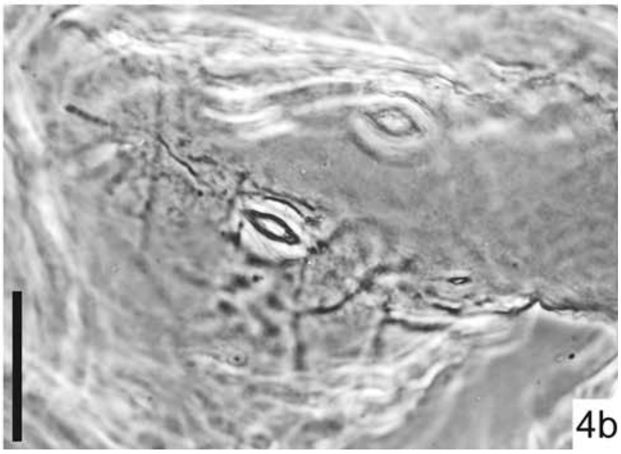
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Plate 11

Dicotylophyllum sp. 2

1a. Adaxial epidermis, specimen No. KRAM-P 243/A/CDisp/188
1b. Abaxial epidermis with stomata. Note the probable idioblast secretory cell (arrow), specimen No. KRAM-P 243/A/CDisp/188

Dicotylophyllum sp. 3

2a. Adaxial epidermis, specimen No. KRAM-P 243/E/CDisp/202
2b. Abaxial epidermis with stoma, specimen No. KRAM-P 243/E/CDisp/202

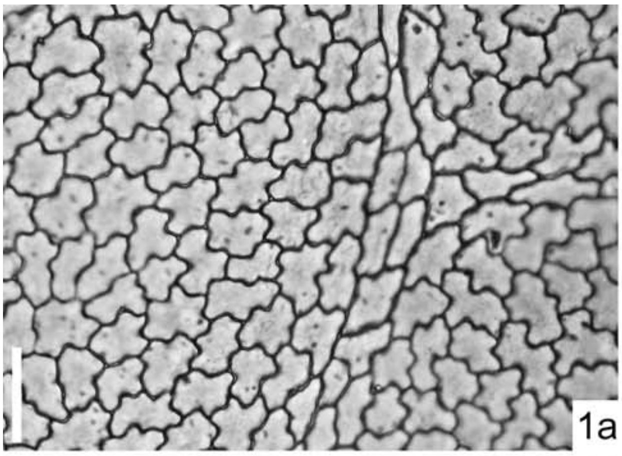
Dicotylophyllum sp. 4

3a. Abaxial epidermis with stomata, specimen No. KRAM-P 243/E/CDisp/218
3b. Enlargement of abaxial epidermis, specimen No. KRAM-P 243/E/CDisp/218

Dicotyledones indeterminatae

4. Probably adaxial epidermis, specimen No. KRAM-P 243/E/CDisp/132
5. Stomata, specimen No. KRAM-P 243/E/CDisp/121

1a, 2a, 3a, b, 4: scale bar – 50 µm; 1b, 2b, 5: scale bar – 25 µm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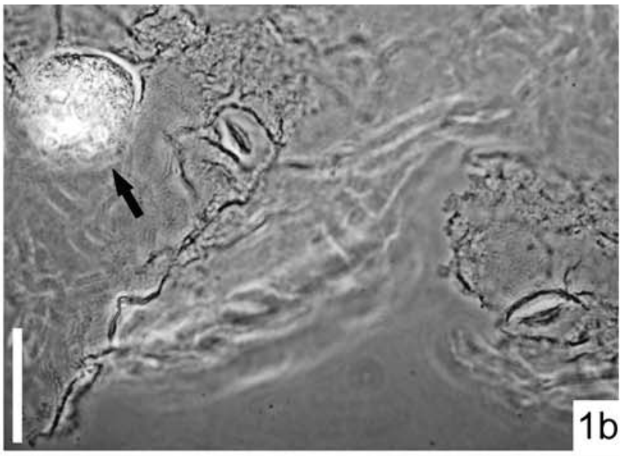
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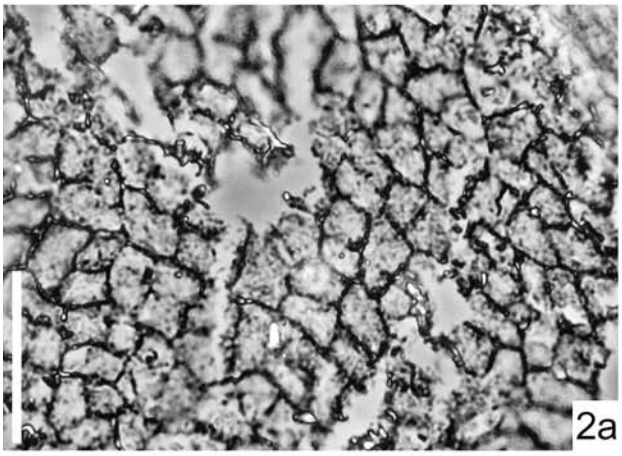
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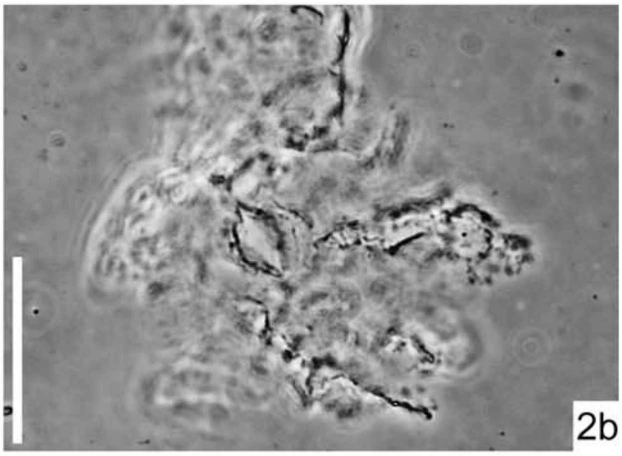
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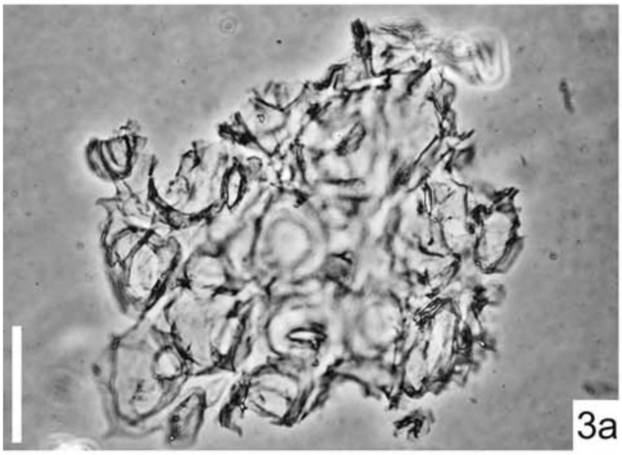
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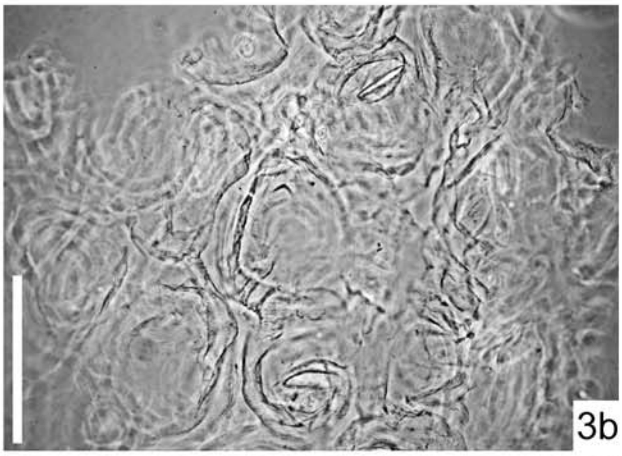
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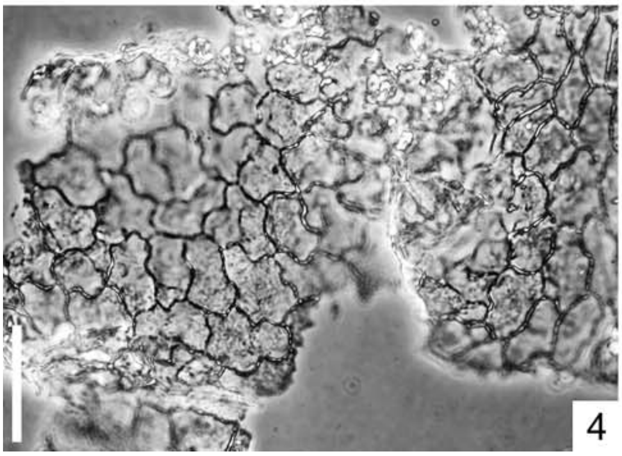
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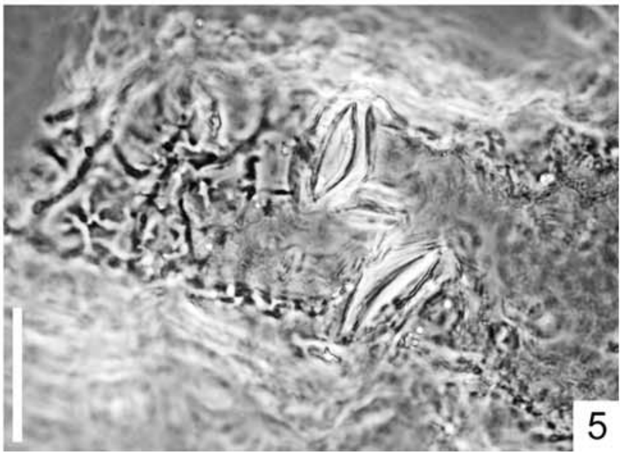
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Plate 12

Zingiberoideophyllum liblarense Kräusel & Weyland

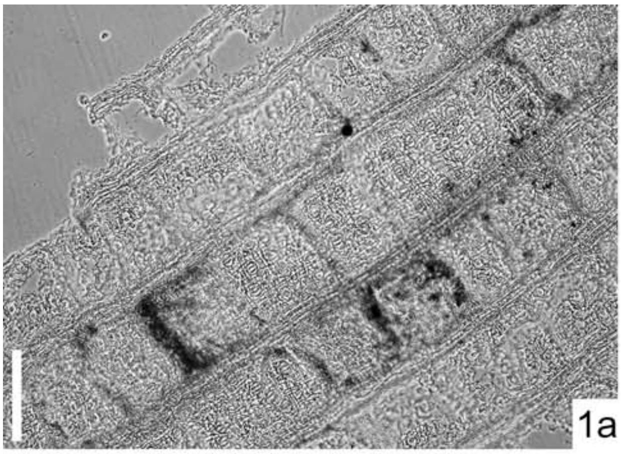
1a. Detail of network of leaf venation. Note the black remnants of secretory cells inside mesophyll, specimen No. KRAM-P 243/A/CDisp/5
1b. Detail of stomata structure, specimen No. KRAM-P 243/A/CDisp/5
2a. Stomatal arrangement on abaxial epidermis, specimen No. KRAM-P 243/A/CDisp/10
2b. Detail of abaxial epidermis and stomata, specimen No. KRAM-P 243/A/CDisp/10

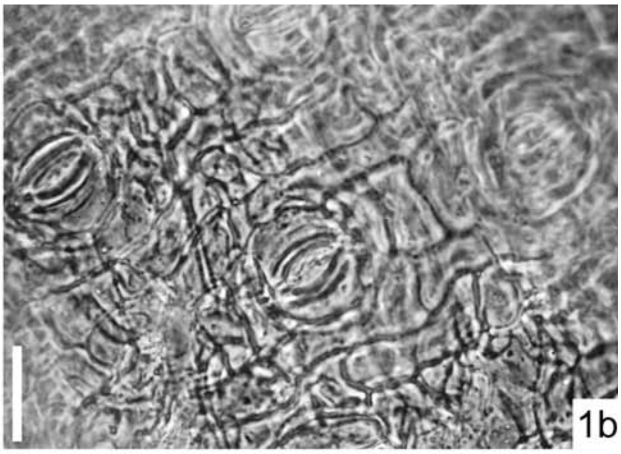
Dioscoreophyllum liblarense Kräusel & Weyland complex
sensu Kvaček & Wilde 2006

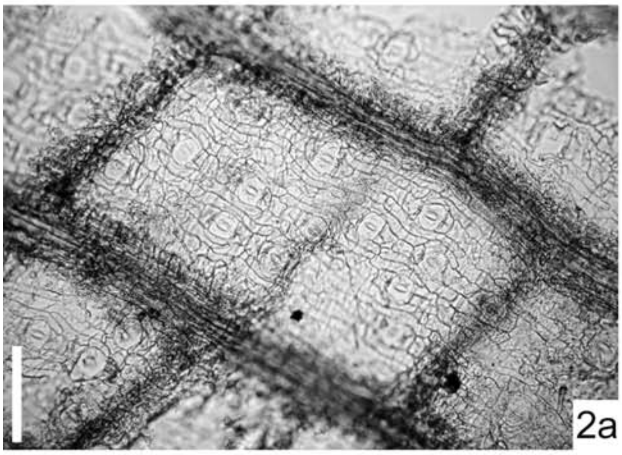
3a. Abaxial epidermis with stoma, specimen No. KRAM-P 244/C/CDisp/1
3b. Fungal hyphae on epidermis, specimen No. KRAM-P 244/C/CDisp/1
3c. Fungal hyphae and epicuticular wax concentrations on epidermis, specimen No. KRAM-P 244/C/CDisp/1
3d. Fungal fructification on epidermis, specimen No. KRAM-P 244/C/CDisp/1

1a: scale bar – 250 µm; 2a: scale bar – 100 µm; 2b, 3a, b, d: scale bar – 50 µm; 1b, 3c: scale bar – 25 µm

Plate 12







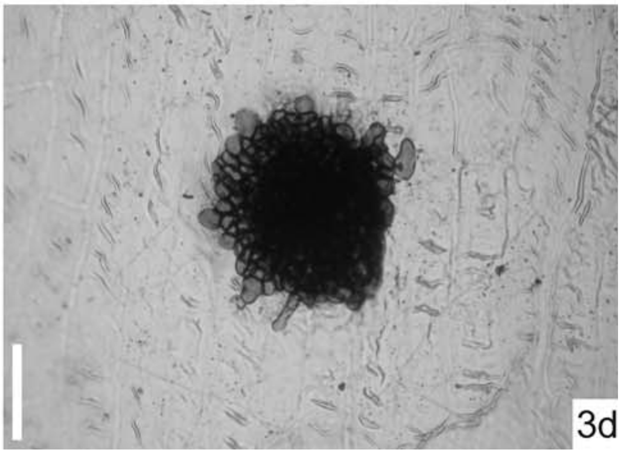


Plate 13

Dioscoreophyllum liblarense Kräusel & Weyland complex sensu Kvaček & Wilde 2006

1a. Adaxial epidermis. Note the cover of epicuticular wax, specimen No. KRAM-P 244/B/CDisp/2

1b. Abaxial epidermis showing detail of structure of aggregations of epicuticular wax crystalloids, specimen No. KRAM-P 244/B/CDisp/2

1c. Abaxial epidermis showing cover of epicuticular wax visible in dark field, specimen No. KRAM-P 244/B/CDisp/2

1d. Abaxial epidermis with stomata and cuticle ornamentation, specimen No. KRAM-P 244/B/CDisp/2

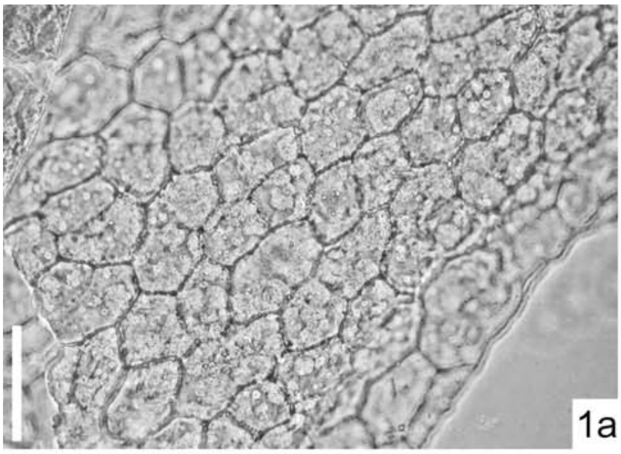
1e. Abaxial epidermis with stomata and cuticle ornamentation, specimen No. KRAM-P 244/B/CDisp/2

2a. Abaxial epidermis with stomata and cuticle ornamentation, specimen No. KRAM-P 244/B/CDisp/1

2b. Detail of stoma, specimen No. KRAM-P 244/B/CDisp/1

3. Detail of cuticle ornamentation, specimen No. KRAM-P 244/B/CDisp/4

1a, d, e, 2a: scale bar – 100 µm; 1b, c, 2b, 3: scale bar – 50 µm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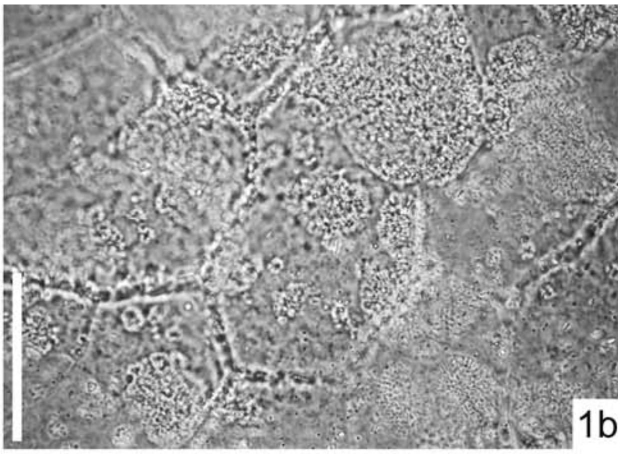
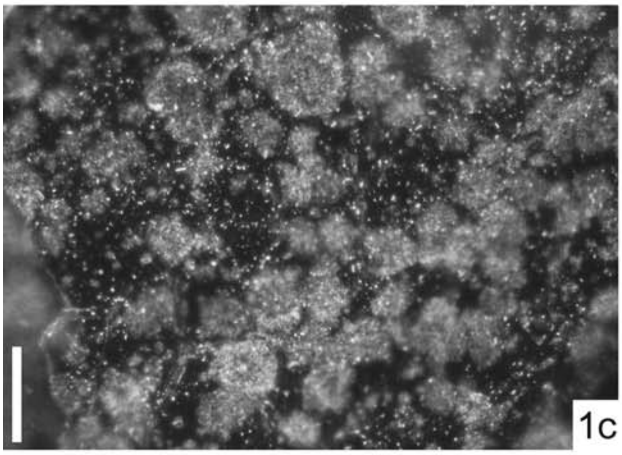
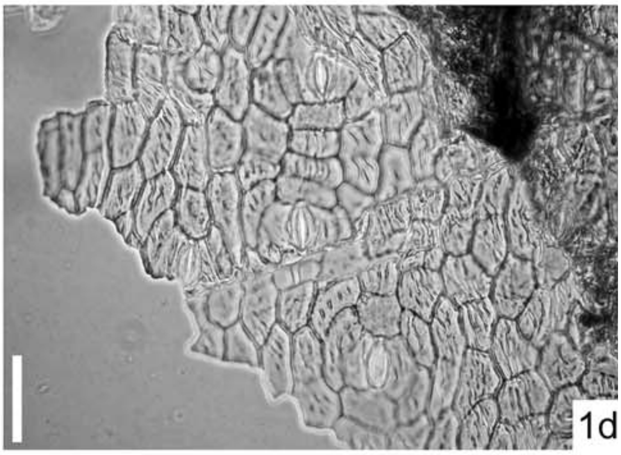

1b


1c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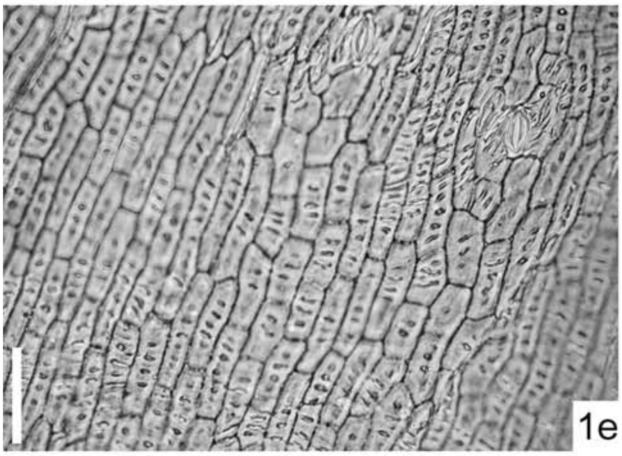
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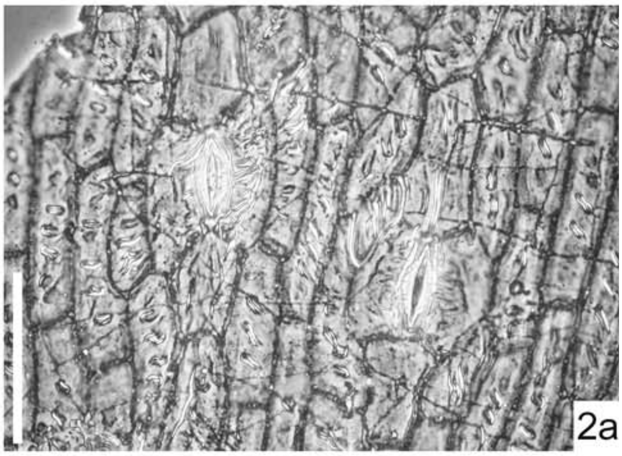
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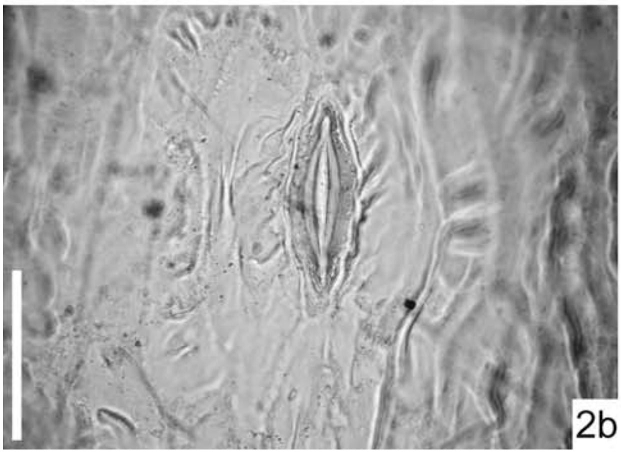
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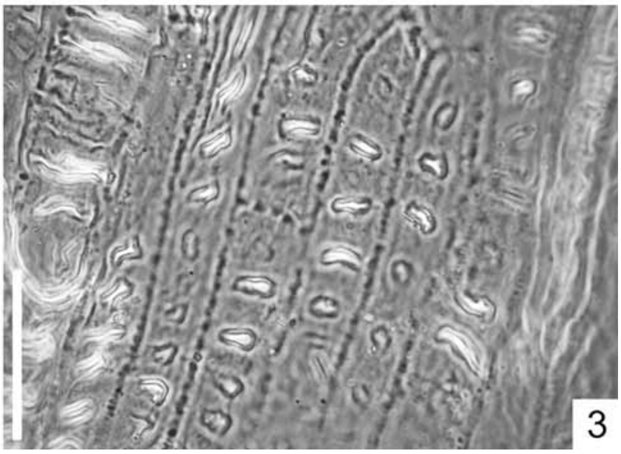
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Plate 14

Dioscoreophyllum liblarense Kräusel & Weyland complex sensu Kvaček & Wilde 2006

1a. Detail of cuticle ornamentation (phase contrast), specimen No. KRAM-P 244/B/CDisp/4
1b. Detail of cuticle ornamentation (dark field), specimen No. KRAM-P 244/B/CDisp/4
2a. Abaxial (?) epidermis. Note the aggregations of epicuticular wax, specimen No. KRAM-P 244/B/CDisp/3
2b. Detail of stoma, specimen No. KRAM-P 244/B/CDisp/3

cf. *Scheuchzeria* sp.

3a. Epidermis with stoma, specimen No. KRAM-P 243/A/CDisp/223
3b. Detail of stoma, specimen No. KRAM-P 243/A/CDisp/223

Animal cuticles

4a. General view, specimen No. KRAM-P 243/E/CDisp/237
4b. Detail, specimen No. KRAM-P 243/E/CDisp/237

1a, b, 2a, b, 3b, 4b: scale bar – 50 µm; 3a, 4a: scale bar – 100 µm

Plate 14

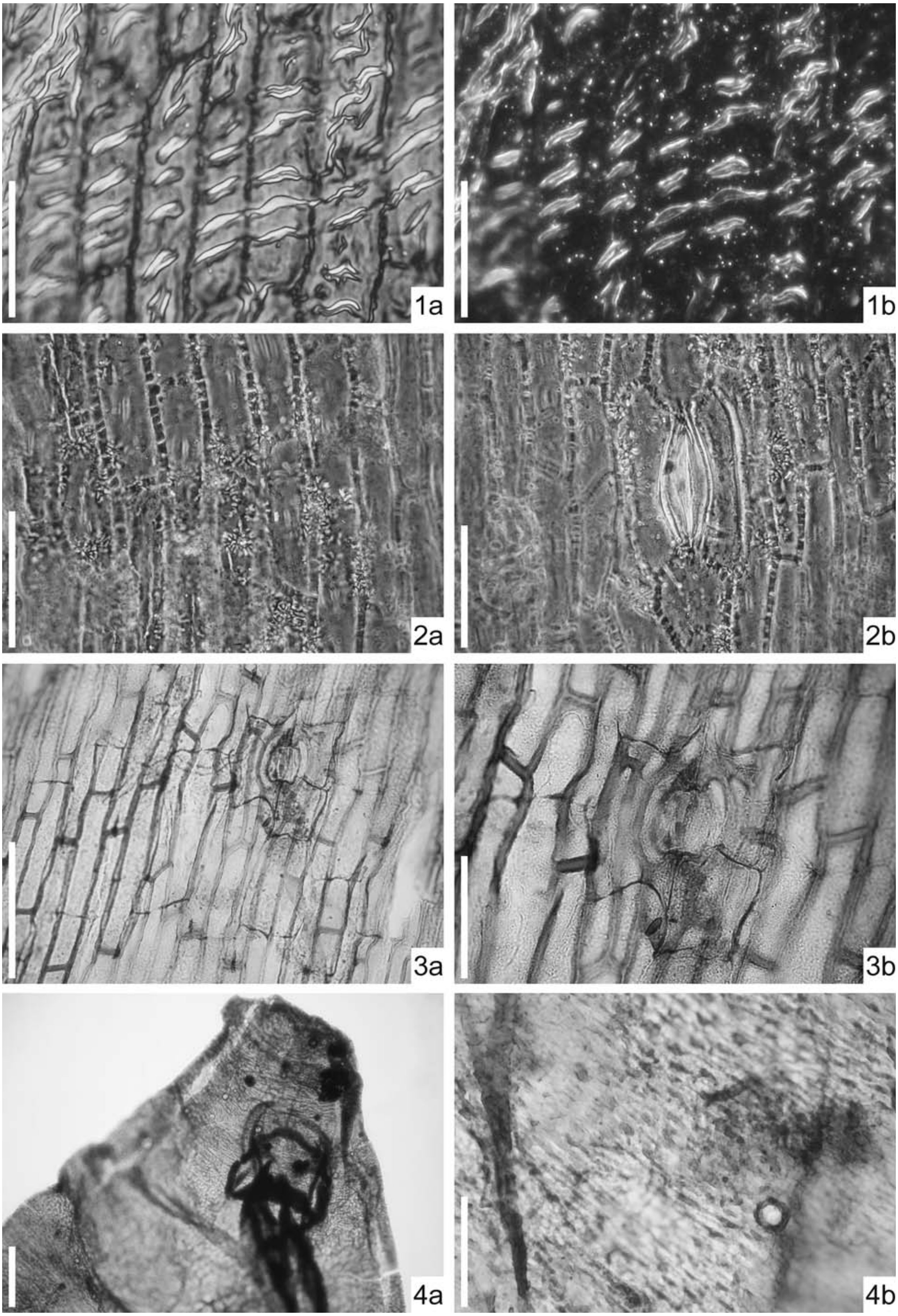
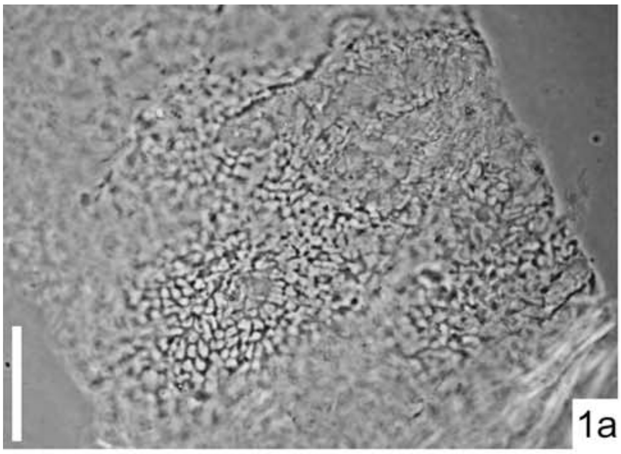


Plate 15

Incertae sedis

1a. Epidermis. Note the dense cuticular ornamentation, specimen No. KRAM-P 243/E/CDisp/222
1b. Epidermal cells. Note the strongly undulate cell walls, specimen No. KRAM-P 243/E/CDisp/222
2a. General view of epidermis, specimen No. KRAM-P 244/C/CDisp/5
2b. Detail of stoma, specimen No. KRAM-P 244/C/CDisp/5
3. Incertae sedis, specimen No. KRAM-P 243/E/CDisp/234
4. Incertae sedis, specimen No. KRAM-P 243/A/CDisp/236
5. Incertae sedis, specimen No. KRAM-P 243/A/CDisp/238
6. Incertae sedis, specimen No. KRAM-P 243/A/CDisp/239

1a: scale bar – 25 µm; 1b; 2b: scale bar – 50 µm; 2a, 3, 4, 5, 6: scale bar – 100 µm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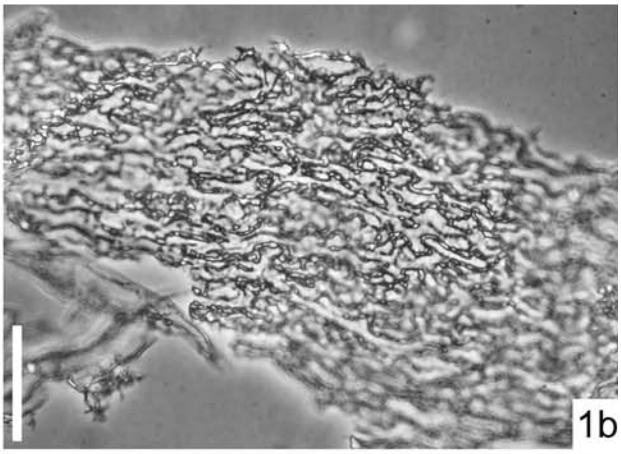
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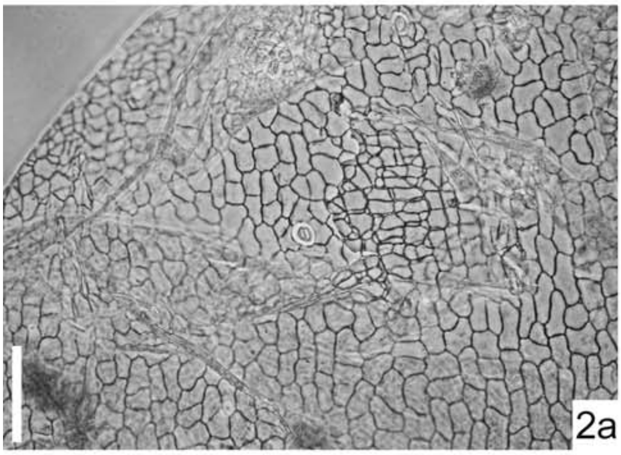
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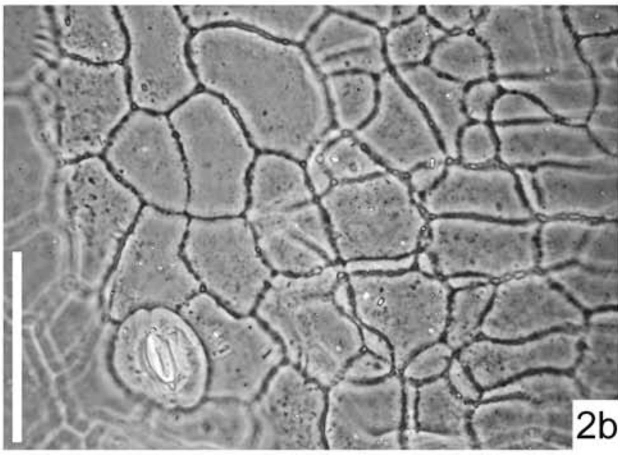
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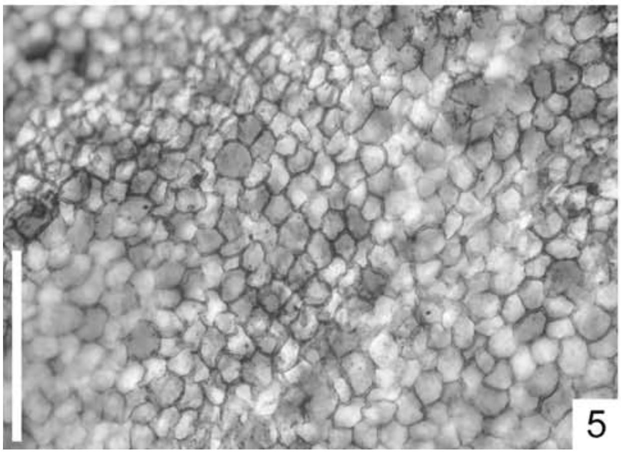
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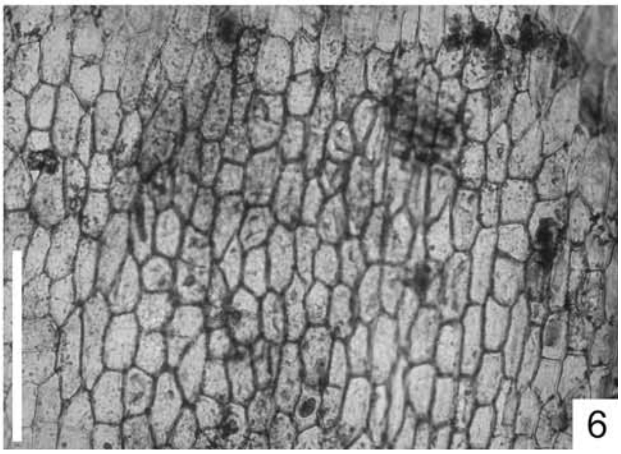
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Plate 16

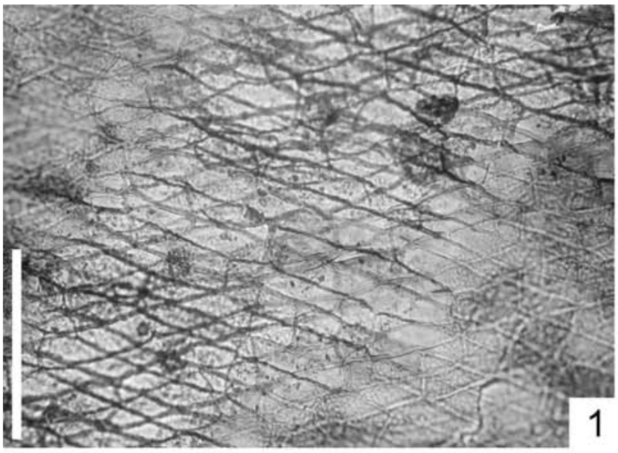
Incertae sedis

1. Specimen No. KRAM-P 243/A/CDisp/237
2. Specimen No. KRAM-P 243/A/CDisp/226
3. Specimen No. KRAM-P 243/E/CDisp/213
4. Specimen No. KRAM-P 243/E/CDisp/226
5. Specimen No. KRAM-P 244/C/CDisp/7
6. Specimen No. KRAM-P 244/C/CDisp/8
7. Specimen No. KRAM-P 243/E/CDisp/232

Microthyriaceous fungus

8. Ascoma, specimen No. KRAM-P 243/E/CDisp/187

1, 2, 5, 6, 7: scale bar – 100 µm; 3, 4, 8: scale bar – 50 µm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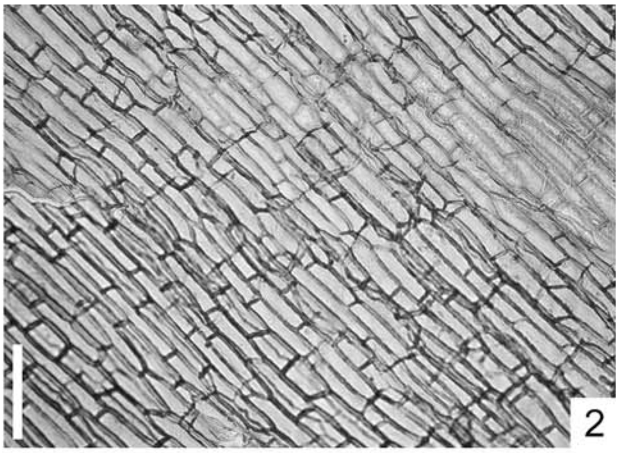
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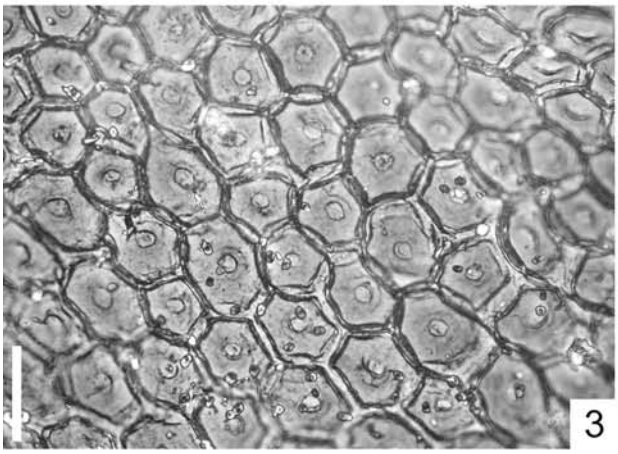
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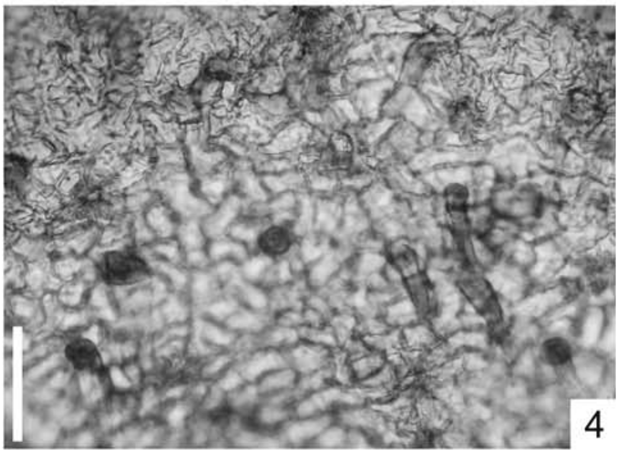
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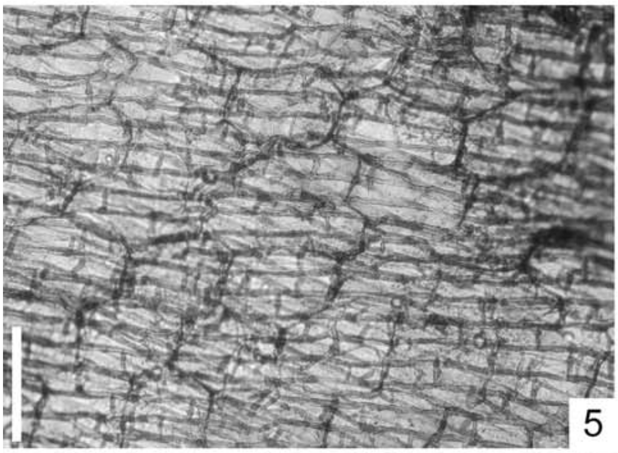
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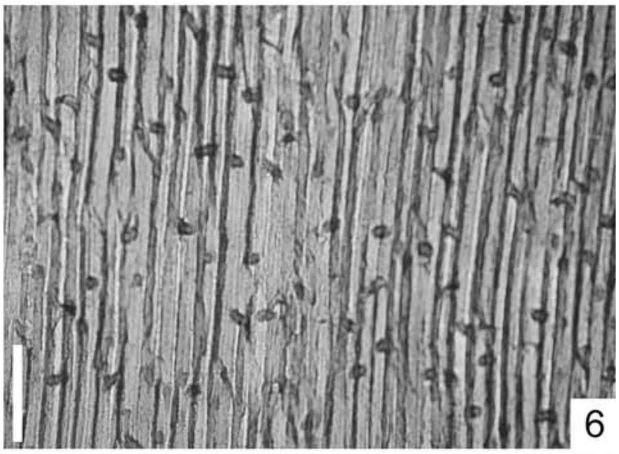
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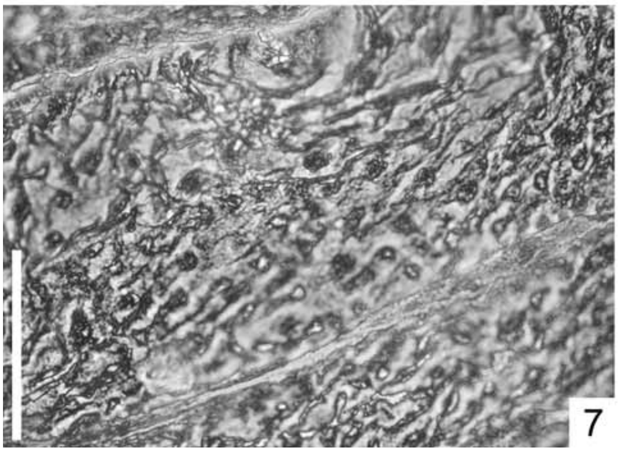
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