Acta Palaeobot. 31 (1,2): 73–151, 1991

THE PLIOCENE LEAF FLORA FROM RUSZÓW NEAR ŻARY IN LOWER SILESIA, SOUTH-WEST POLAND. PART II (*Betulaceae*)

Plioceńska flora liściowa z Ruszowa koło Żar na Dolnym Śląsku, Polska południowo-zachodnia. Część II (*Betulaceae*)

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ABSTRACT. The results of studies on the fossil remains of *Betulaceae* family (leaves and involucres) and of *Dicotyledoneae* incertae sedis are presented, as a continuation of investigating leaf remains from the deposits of Gozdnica Series at Ruszów near Żary (Hummel 1983). Based on comparative morphological and anatomical studies, among the remains of family *Betulaceae*, species of the following genera have been distinguished: *Alnus*, *Betula*, *Carpinus* (most numerous), *Corylus* and *Ostrya*. New species of fossil birch *Betula plioplatyptera* sp. nov. is described. For the first time cuticles of *Betula subpubescens* Goepp., *Corylus avellana* L. foss. and *Ostrya carpinifolia* Scop. foss. are investigated.

KEY WORDS: Pliocene, leaves, fruits, morphology, anatomy, *Betulaceae*

INTRODUCTION

The geological situation of the fossil flora from Ruszów (Fig. 1) and the earlier results of paleobotanical studies were discussed in the publication "The Pliocene leaf flora from Ruszów near Żary" (Hummel 1983). It contained the results of the morphological and anatomical investigation of 383 leaf, shoot and fruit remains from 30 fossil taxons representing the families: *Taxodiaceae, Myricaceae, Juglandaceae, Salicaceae, Fagaceae, Ulmaceae, Hamamelidaceae, Aceraceae, Trapaceae, Oleaceae* and *Zingiberaceae*. Due to significant prevalence of remains from family *Betulaceae*, their analysis was then postponed to a separate paper. In the paper of 1983 they were simply reported as leaves of *Betulaceae* gen. et sp. div. and involucres of *Carpinus* sp.

In this publication the results of comparative morphological and anatomical studies of 128 *Betulaceae* remains and of two *Dicotyledoneae* incertae sedis leaf fragments are presented. The investigated material consists of clay impressions of plants mostly with preserved organic substance (79 specimens) and of macroscopic slides of leaves (51 specimens) prepared from leaf layers using the method described earlier (Hummel l.c.). The

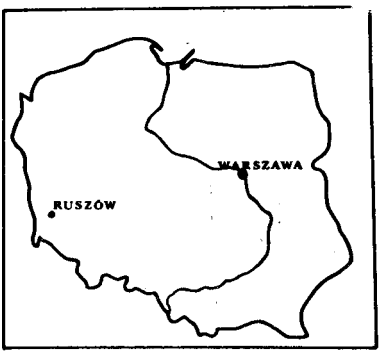


Fig. 1. Localisation of the fossil flora of Ruszów

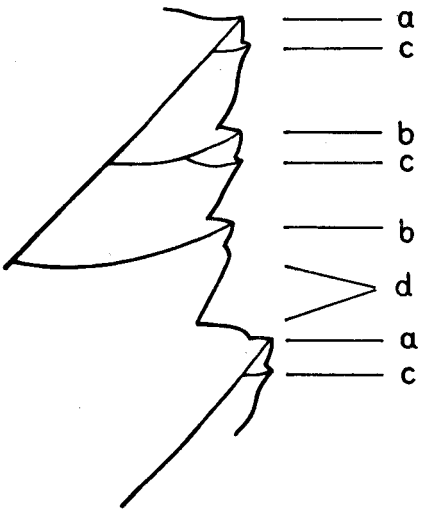


Fig. 2. The pattern of leaf margin development in *Betulaceae* adopted in this paper: a – primary tooth, b – secondary tooth, c – additional tooth, d – convexities

pattern seen in Fig. 2 illustrates the terms used in descriptions of leaf margin development in *Betulaceae*.

DESCRIPTION OF THE PLANT REMAINS

Alnus julianaeformis (Sternberg) Kvaček et Holý

Pl. 1, fig. 1–5, Pl. 2, fig. 2; Fig. 3: 1–8

1823. *Phyllites julianaeformis* Sternb.; Sternberg, p. 37, 39, Pl. 36, Fig. 2.
1974. *Alnus julianaeformis* (Sternb.) Kvaček et Holý; Kvaček & Holý, p. 368, Pl. 1–3, Pl. 4, fig. 1; Fig. 1.

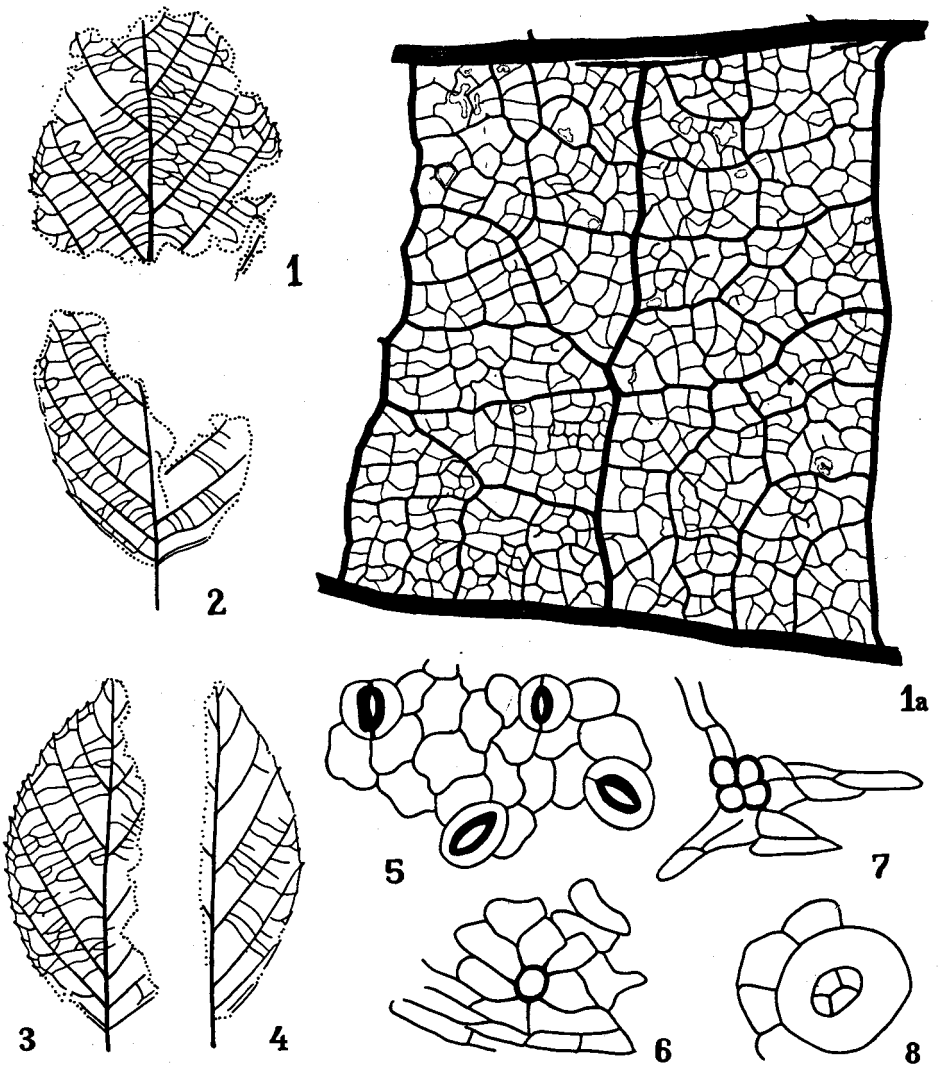


Fig. 3. *Alnus julianaeformis* (Sternberg) Kvaček et Holý. 1 – specimen No MZ.VII/67/I/11, x 1; 1 a – higher order venation, x 14, drawing by J. Wieser; 2 – specimen No MZ.VII/67/0/39, x 1; 3 – specimen No MZ.VII/67/I.63, x 1; 4 – specimen No MZ.VII/66/8/166, x 1; 5 – lower epidermis, stomata, specimen No MZ.VII/67/I/63, x 500; 6 – lower epidermis, circular trichome base, specimen No MZ.VII/67/I/ 11, x 500; 7 – lower epidermis, four-celled base of glandular hair, specimen No MZ.VII/67/I/63, x 500; 8 – glandular hair, specimen No MZ.VII/66/8/166, x 500

Material. Layer 8/2: Nos. MZ. VII/66/8/ 139, 166; Layer 8/WL.O: No MZ. VII/67/0/39; Layer 8/Wl.I.: Nos. MZ. VII/67/I/ 11, 63; five leaf fragments, including two with preserved apex and four with leaf base.

Morphological description. Leaves elliptic, widest at the half of the length of lamina. Leaf apex short acuminate, base cuneate. The length of most complete leaves

about 5.0 cm, width 2.3–2.8 cm. The width of the largest leaf 3.3 cm. Fragments of leaf petiole about 0.5 cm long. Leaf margins entire at the base, higher up finely serrate. Teeth with terminating secondaries about 0.6 mm high and 1.0–1.5 (2.0) mm wide at the base. Tooth apex acute, apical angle acute, apical side short, straight, less often convex or acuminate, basal side longer than apical, concave or acuminate. Between two adjacent secondaries, 0–3 (5) teeth observed with terminating veins of the third and higher orders, somewhat smaller than teeth with terminating secondaries; sometimes barely marked; their apical angle usually more acute. Sinuses between teeth angular.

Venation pinnate, simple craspedodromous, at the basal part of leaf sometimes nearly semicraspedodromous (Fig. 3: 3). Primary vein straight, moderate, tapering gradually toward leaf apex. Seven to eight pairs of secondary veins branching from the midvein at intervals of (3) 7–9 mm at the angle of 35–45 (55)°. The lowermost secondaries sometimes arranged almost oppositely, the higher ones alternating. Secondaries running straight or slightly arcuate, sporadically upturned before entering the teeth. Right at leaf base, along its margin a pair of thin veins observed, vanishing in the loops of tertiaries. No intersecondary veins observed. Tertiary veins percurrent, perpendicular or oblique to secondaries, simple when arranged suboppositely, or forked half-way between adjacent secondary veins when arranged alternately. The frequency of the tertiaries reaching 6–8 per 1 cm of secondary vein length.

In the marginal part of leaf, tertiary veins slightly thicker and bent; from bending points leave nerves entering teeth. In the basal part of leaf, tertiary veins near leaf margin forming loops from which fine veins run toward teeth. Higher order venation mostly of orthogonal course (Fig. 3: 1a). Areoles well developed or imperfect, arrangement of areoles random or oriented. Veinlets none or simple, poorly visible. Marginal ultimate venation looped.

Anatomical description. Upper epidermis. Cells polyhedral, mostly pentagonal, isodiametric or slightly elongated with their longest diagonal being 10–18 (22) μm. Anticlinal walls of cells (3) 5–13 (16) μm in length, straight or rounded, slightly uniformly cutinized (Pl. 1, fig. 5). Sporadically occurring subisodiametric, 13–15 μm in diameter, four-celled bases of glandular hairs of walls more cutinized than the walls of the other basic epidermal cells.

Lower epidermis. Cells polygonal, isodiametric or slightly elongated, 10–16 (22) μm in the longest diagonal. Anticlinal walls of cells slightly cutinized, slightly undulate, sometimes straight or rounded. Length of walls, measured along straight line, fluctuating within limits 3–13 (16) μm.

Stomatal apparatus anomocytic. Stomata circular or oblong (Pl. 2, fig. 2; Fig. 3: 5), (13) 16–20 (22) μm in length and 13–15 (18) μm in width; irregularly distributed in non-venous areas. Epidermal walls of guard cells slightly cutinized. Immediately visible distinct thick outer stomatal ledges surrounding spindle-shaped apertures, 6–11 x 1–3 μm in size. Sometimes thickening of ledges going as far as stomatal poles. Apertures together with outer stomatal ledges are 10–13 (15) x 5–8 (10) μm in size. Among the cells of lower epidermis, primarily over the veins or in their vicinity, four-celled (very rarely five and six-celled) bases of glandular hairs (Pl. 2, fig. 2; Fig. 3: 7) often found,

with diameter being 13–18 μm. Only one poorly visible glandular hair with a disc about 35 μm in diameter and a four-celled gland base 15 x 11 μm in size found in a small cuticular fragment which is hard to classify as lower or upper epidermis (Fig. 3, 8). In addition to four-celled bases of glandular hairs small circular trichome bases about 10 μm in diameter sporadically occurring near the veins of the lower epidermis (Fig. 3: 6) The latter bases surrounded by radially arranged trichome-base cells of more cutinized poral and radial walls.

Comparison. The leaves of this fossil species were described for the first time from the North Bohemian Basin near Bilina (Czecho-Slovakia) by Sternberg (1823) under the name *Phyllites julianaeformis* Sternb. Unger (1845) included them in *Fagus* and described the Bilina leaves as *Fagus feroniae* Ung. Heer (1868) and Lesquereux (1878) questioned the assignment of those leaves to this genus. Saporta (1891–1892) and Ettingshausen (1894) pointed out a strong similarity of the leaves of this taxon from the Manosque, Bilina and Leoben area to *Alnus* leaves. It was confirmed by Czeczott (1934). She found out that the pattern of leaf margins in this taxon is typical of alder, especially with its more or less numerous subsidiary teeth, secondary veins of arcuate course, and with characteristic bendings of tertiary veins in the marginal part of the leaf.

Based on the priority work of Sternberg (1823), Kvaček and Holý (1974) introduced the name of *Alnus julianaeformis* (Sternb.) Kvaček et Holý for this form of leaves. Due to the lack of holotype they chose a neotype which is a specimen from the same area from the so called Brestany clays, investigated by Czeczott (1934, Textfig. 30 left.). Kvaček & Holý (l.c.) also described the anatomical structure of this species.

General shape of the leaves from Ruszów, development of leaf margins, and the type of venation of the second and higher orders allow to designate those remains as *Alnus julianaeformis* (Sternb.) Kvaček et Holý. The epidermal structure of those leaves corresponds to the one presented by Kvaček (Kvaček & Holý l.c.), and also to the one from the Miocene floras of Wackersdorf (Knobloch & Kvaček 1976) and Søby-Fasterholt (Christensen 1976). Therefore for the Ruszów specimens the author of this paper uses the name *Alnus julianaeformis* (Sternb.) Kvaček et Holý although Iliinskaya (1978) and Givulescu (1979) question the idea of relating *Alnus feroniae* Ung. to the remain described by Sternberg.

Leaves of *A. julianaeformis* (Sternb.) Kvaček et Holý are known from the floras of the European Neogene (Czeczott 1934). They were most numerous in the floras of the Lower and Middle Miocene, first of all in the floras of Bilina (Kvaček & Holý 1974) and of Leoben (Ettingshausen 1894). They are also reported from the Lower Lusatia (Menzel, Gothan & Sapper 1933), Lower Rhine Basin (Kilpper 1971), Wackersdorf (Knobloch & Kvaček 1976), Søby (Christensen 1976) and Linschig near Tamsweg (Knobloch & Kvaček 1982). Zastawniak (1980) reports this species from the Sarmatian of the Holý Cross Mountains, it is also known from the Upper Miocene flora of Sośnica (=*Quercus attenuata* Goepp., Knobloch 1971), and from Pannonian floras of Romania (Givulescu 1957) and Transcarpathian regions (Iliinskaya 1968). Recently Kovar (1982) assigned a leaf fragment of *Alnus feroniae* (Ung.) Czeczott from the Upper Oligocene of the Linz area.

As far as morphological structure is concerned, the leaves of *Alnus julianaeformis* (Sternb.) Kvaček et Holý correspond best to the recent species of *Alnus japonica* Sieb. et Zucc. (Pl. 1, fig. 6) which occurs in Japan, China and Eastern Russia but they differ in terms of anatomical structure (Kvaček & Holý 1974, also observations of the author). The stomata, trichome bases, and cells of the upper and lower epidermis of *A. japonica* are larger, the anticlinal cell walls of the upper and lower epidermis are straight. According to Kvaček (Kvaček & Holý 1974), the epidermis of *Alnus julianaeformis* (Sternb.) Kvaček et Holý is most similar to the recent species of *Alnus trabeculosa* Handel-Mazzetti which grow in the South-East China. The examination of this taxons cuticles (Pl. 2, fig. 1) and comparison to the leaves from Ruszów confirm this opinion. The cells of the upper and lower epidermis of fossil and recent leaves are similar in size and shape, and so are the size and structure of stomata and of the bases of glandular hairs. Presumably the difference is only in the size of glandular hair discs. The diameter of the only glandular hair discs preserved in Ruszów leaves is approximately 35 μm, whereas in *A. trabeculosa* it varies between 50 and 70 μm. In terms of morphological structure, the leaves of *Alnus trabeculosa* Handel-Mazzetti differ from the fossil taxon primarily in that they often have an asymmetric, rounded to cordate base and more numerous secondary veins (10–12 pairs).

Occurrence in Poland's fossil floras. Dzierżysław (Unger 1845), Sośnica (as *Quercus attenuata* Goepp., Knobloch 1971), Młyny (Zastawniak 1980).

Reference herbarial materials:

Alnus japonica Sieb. et Zucc. – Manchuria, leg. D. Litvinov LE; Hokkaido Prov., coll. H. Koyama, det. N. Fukuoka 185 LE; Nippon, leg. Maximovich, det. Cherepanov LE; coll. H. Czeczott WA ME; Yomamoto in Settsu, coll. M. Togasi 2404 W; Japan, 5201 W

Alnus trabeculosa Hand.-Maz. – Kvangtung, coll. W. T. Tsang, det. E. D. Merrill 4621 W; Prov. Hunan, coll. H. Handel-Mazzetti 2730 WU

Alnus menzelii Raniecka-Bobrowska

Pl. 2, fig. 4; Fig. 4

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

Material. Layer 8/1: No MZ.VII/66/8/ 30; one leaf fragment with preserved base.

Morphological description. Basal part of probably wide elliptic-ovate leaf about 9.0 cm long (length of preserved fragment 7.5 cm), and of maximal width of 6.8 cm observed somewhat below the middle of lamina length. Leaf base distinctly cordate, slightly asymmetric. Petiole missing.

Leaf margin poorly preserved, finely biserrate, entire at the base. Primary teeth with acute or right apical angle, both sides acuminate, about 2.0 mm wide at the base. Secondary teeth fine, flat, with apical side short, and basal side acuminate, straight or convex, long. Sinuses between teeth angular.

Venation pinnate, simple craspedodromous. Midvein moderate. Secondary veins (8 pairs preserved) arranged almost oppositely at the base, higher up alternating, straight or slightly arcuately upturned. Two lowermost pairs strongly arcuate, initially running down at

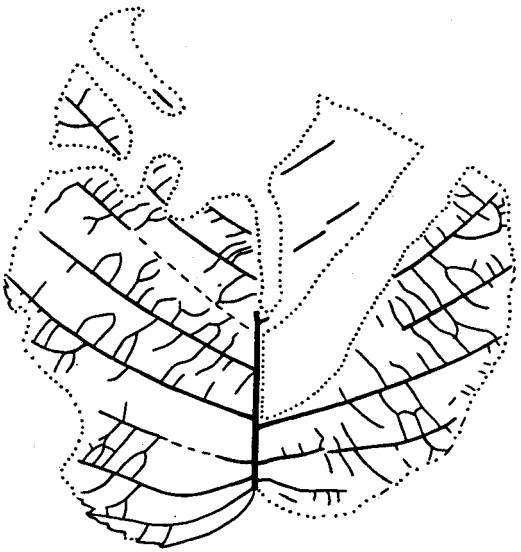


Fig. 4. *Alnus menzelii* Raniecka-Bobrowska, specimen No MZ.VII/66/8/30, x 1

the angle 100–125° and then turning upward. Intervals between the secondaries irregular, 1–3 mm at the leaf base and 5–8 mm higher up. The angle of divergence between the midvein and the secondary veins (except for two lowermost pairs) being 65–75° in the basal part of leaf, and 55–65° in its central part. The lower secondaries with few outer branches. Intersecondary veins not observed.

Tertiary veins percurrent, branching from secondaries at the right or acute angle, usually forked more or less half-way between the adjacent secondaries, sometimes simple. In basal part of leaf tertiaries running irregularly, 4–5 per 1 cm of secondary vein length, higher up more regular, about 7 per 1 cm of the lateral vein length. Higher order venation predominantly orthogonal. Areoles well developed. Marginal ultimate venation not visible.

Anatomical description. Cuticle poorly preserved. Only isodiametric or slightly elongated cells of upper epidermis visible, their longest diagonal fluctuating within limits of 16–24 (30) μm; anticlinal walls of cells 8–20 (24) μm in length, straight or slightly rounded, slightly, uniformly cutinized. Other epidermal formations unknown.

Comparison. The specimen from Ruszów should be included in *Alnus* due to its leaf shape, margin development and the pattern of the secondary and higher order veins. It is closest to the *Alnus menzelii* Ran.-Bobr. from Konin described by Raniecka-Bobrowska (1954). The only minute difference occurs in the tertiary venation pattern – it is more dense in the leaves from Konin. Raniecka-Bobrowska (l.c.) pointed out to significant similarity of the remains from Konin to *Corylus Mac Quarrii* Forbes from Koronowo (Menzel 1910) and stated that all those are alder leaves and that they belong to *A. menzelii* Rand.-Bobr. This species probably occurred also in the Upper Miocene flora of

Dobrzyń on the Vistula. The shape of the leaf lamina and the secondary venation pattern of the leaves from that flora, assigned by Kownas (1956) to *Betula macrophylla* (Goepp.) Heer, are characteristic of *A. menzelii* Ran.-Bobr.; also, they have a similar type of leaf margin serration.

Leaf specimens from Rozewie, known as *Alnus kefersteinii* Goeppert (Heer 1869b), are another taxon of fossil alder. Their secondary veins are less numerous (usually 8 pairs), they run at larger intervals, have a lot of outer branches, and the departure angle from the midvein in the basal part of the leaf is usually acute. *Alnus suborientalis* Czecz. et Skirg. (Czeczott & Skirgiełło 1967) leaves from the Lower Miocene flora of Turów are also different from *A. menzelii* Ran.-Bobr. They have different serration pattern of leaf margins with larger teeth, and less numerous secondary veins running in larger intervals.

Recently Knobloch (1986) has found *Alnus menzelii* Ran.-Bobr. leaves in the Sarmatian flora of Achldorf near Vilsburg and compared them with some taxa of fossil leaves from the European and Asian Tertiary.

According to Raniecka-Bobrowska (1954), the leaves of *Alnus menzelii* Ran.-Bobr. resemble two recent species of *A. subcordata* C. A. Mey. and *A. serrulata* Willd. The leaves of *A. subcordata* are similar in shape but they usually have simple serrate margins, whereas the leaves of *A. serrulata* have similar leaf margins but the leaves have a more elongated shape. These observations have been confirmed by the analysis of the herbarial materials. The materials contain *A. subcordata* C. A. Mey. leaves with the type of tertiary venation very similar to that of the leaf from Ruszów.

Today *Alnus subcordata* C. A. Mey. occurs in the Caucasus and in Iran in broad-leaved forests up to 1,000 m above sea level, and is often found on the stream banks (Sokolov 1951). *A. serrulata* Willd. grows in the forests of the eastern part of the United States (Krüssmann 1976).

Occurrence in Poland's fossil floras. Konin (Raniecka-Bobrowska 1954), Koronowo (as *Corylus Mac Quarrii* Forbes, Menzel 1910), Dobrzyń (as *Betula macrophylla* (Goepp.) Heer, Kownas 1956).

Reference herbarial materials:

Alnus serrulata Willd. – Black Rock, Virginia, coll. F. R. Fosberg and E. H. Walker 4275 and 2264 W; flora of Washington, det. A. Callier 1725 WU; Florida, coll. Nash, det. A. Callier 1725 W

Alnus subcordata C. A. Mey – Lencoran leg. Hohenacker, det. H. Winkler W; Lencoran, leg. Hohenacker, det. H. Winkler 245281 W; Caucasus LE

Alnus sp.

Pl. 2, fig. 3, 3a; Fig. 5: 1, 2

Material. Layer 8/1 No MZ. VII/66/8/ 49; Layer 8/2: No MZ.VII/66/8/ 182; two leaf fragments with partly preserved bases.

Morphological description. Leaves elliptic in outline, with apex missing and base damaged, probably rounded. Width of leaves 2.5–3.0 cm. Dimensions of two preserved fragments 3.5 x 2.9 and 2.5 x 2.3 cm.

One impression showing entire margin at the leaf base, higher up leaf margins finely

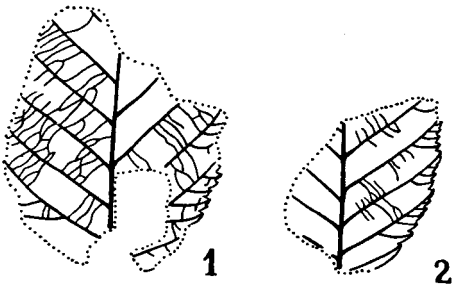


Fig. 5. *Alnus* sp. 1 – specimen No MZ.VII/66/8/49, x 1; 2 – specimen No MZ.VII/66/8/182, x 1

doubly serrate, slightly emarginate. Teeth of first order (with terminating secondaries) usually poorly preserved, 0.5–1.0 mm high and 1.0–1.5 mm wide at the base; their apical side acuminate, basal side acuminate or convex, longer than apical side; basal side sometimes including an additional tooth. There to five teeth of second order between two adjacent secondaries having apical side straight and short; basal side acuminate, convex or straight, long, sometimes with small additional tooth or barely marked convexity. Sinuses between teeth angular.

Venation pinnate, simple craspedodromous. Primary vein moderately thick. Secondary veins (the preserved 5 pairs) straight or slightly curved, arranged alternately or subopositely, branching from midvein at intervals (3) 4–6 mm, at the angle of 45–55 (65)° increasing towards the leaf base and sometimes different on each side of midvein. Near leaf margins 3–5 distinct, usually arcuate outer branches leaving each secondary vein. The number of branches increasing toward leaf base. A vein, somewhat thinner than the secondaries, observed at the base of one specimen; running almost parallely to the entire base and reaching the sinus over the lowermost tooth.

Tertiary veins percurrent, distinctly marked, 12–14 per 1 cm of secondary vein length, simple or forked approximately half-way between two adjacent secondaries, arranged perpendicularly or somewhat obliquely to them. Higher order venation of orthogonal course. Areoles well developed. Marginal ultimate venation looped.

Anatomical description. No cuticle could be separated from the preserved leaf fragments.

Comparison. The venation of both specimens from Ruszów is characteristic of *Alnus* leaves and they mostly resemble the remains of this genus reported as *Alnus rotundata* Goepp. by Menzel (1906, Pl. 2, fig. 8; Pl. 3, fig. 3) from the area of Senftenberg. Their leaves have identical elliptic shape, the lamina being widest approximately in the middle of its length, and similar secondary venation pattern. Also leaf margins are characteristically slightly emarginate; emarginations are missing, however, in a type specimen of *Alnus rotundata* Goepp. from Sośnica (Goeppert 1855, Pl. 4, fig. 4). Therefore, in the opinion of this author, Menzel (l.c.) used the name *A. rotundata* Goepp. incorrectly; it should not be used in reference to fossil alder leaves with emarginate margins. This also refers to *Alnus rotundata* Goepp. leaves from Konin (Raniecka-Bo-

browska 1954, Fig. 9, 10), which have margins of similar emargination.

The leaves from Ruszów very much resemble recent *Alnus incana* (L.) Moench. in overall shape of lamina, margin development and venation pattern of the second and higher orders. They differ from the latter by less distinct emargination and by size of the departure angle of secondaries from midvein. The angles are similar in the basal part of leaf, whereas in the central part they are more acute (approx. 40°) in recent leaves than in fossil leaves (approx. 45°). Based on the analysis of the herbarial materials from various localities it has been stated that although leaf margin development and venation pattern of *Alnus* sp. leaves from Ruszów are similar to those of *Alnus incana* (L.) Moench, the size of departure angle makes them most similar to leaves of *Alnus rugosa* (DuRoi) Spreng. var *americana* (Regel) Fern. which today grows in the eastern part of North America.

Occurrence in Poland's fossil floras. Konin (as *Alnus rotundata* Goepp., Raniecka-Bobrowska 1954).

Reference herbarial materials:

Alnus incana (L.) Moench – E. Tyrol, Hinterbichl in Virgental, coll. H. Handel-Mazzetti 5945 W; N. Italy, coll. Rainer 20803 W; Lower Austria, region Melk, coll. Patzak 8716 W; Kodor river, leg. Shakryl, det. A. A. Kolakovsky 22769 Herb. of Bot. Gard. Sukhumi

Alnus rugosa (DuRoi) Spreng. – *Alnus incana* ssp. *rugosa* DuRoi – Canada Marmora Township, coll. J. M. Gillert 25962 W; Canada, Haycock Island in Shirley Bay, coll. W. G. Dore, L. Bowden 1136 W

Alnus rugosa (DuRoi) Spreng. var. *americana* (Regel) Fern. – Sommerset Co, Maine, coll. J. F. Collins 20207 W

Betula plioplatyptera Hummel sp. nov.

Pl. 3, fig. 1–3, Pl. 4, fig. 1, 1a, Pl. 5, fig. 1–4; Fig. 6: 1–7

Holotypus. Specimen No MZ.VII/67/0/ 26, Pl. 3, fig. 1, 1a; Fig. 6: 1, 1a

Paratypus. Specimen No MZ.VII/67/0/ 24, Pl. 4, fig. 1, 1a, Pl. 5, fig. 2–4; Fig. 6: 2, 20

Locus typicus. Ruszów, Jelenia Góra Voivodship, Poland

Stratum typicum. Gozdnica Series, Pliocene.

Derivato nominis. Species close to Oligocene birch *Betula platyptera* Ettingshausen 1872.

Diagnosis. Leaves elliptic or slightly elliptic-ovate, base cuneate. Leaf margins at the base entire, higher up distinctly doubly serrate. Venation craspedodromous. The lowermost pair of secondary veins running parallely to leaf base. Tertiary veins percurrent, irregular. Cells of upper and lower epidermis isodiametric or slightly elongated, their anticlinal walls straight or rounded. Stomatal apparatus anomocytic. Stomata elliptic or oblong. Only outer stomatal ledges surrounding spindle-shaped or oblong outer stomatal ledge aperture are thicker. Trichome bases of two types: multicellular and unicellular.

Betula subpubescens Goepp. p. p.; Shvareva 1983, p. 79, pl. 77, fig. 1; Text-fig. 14: 6

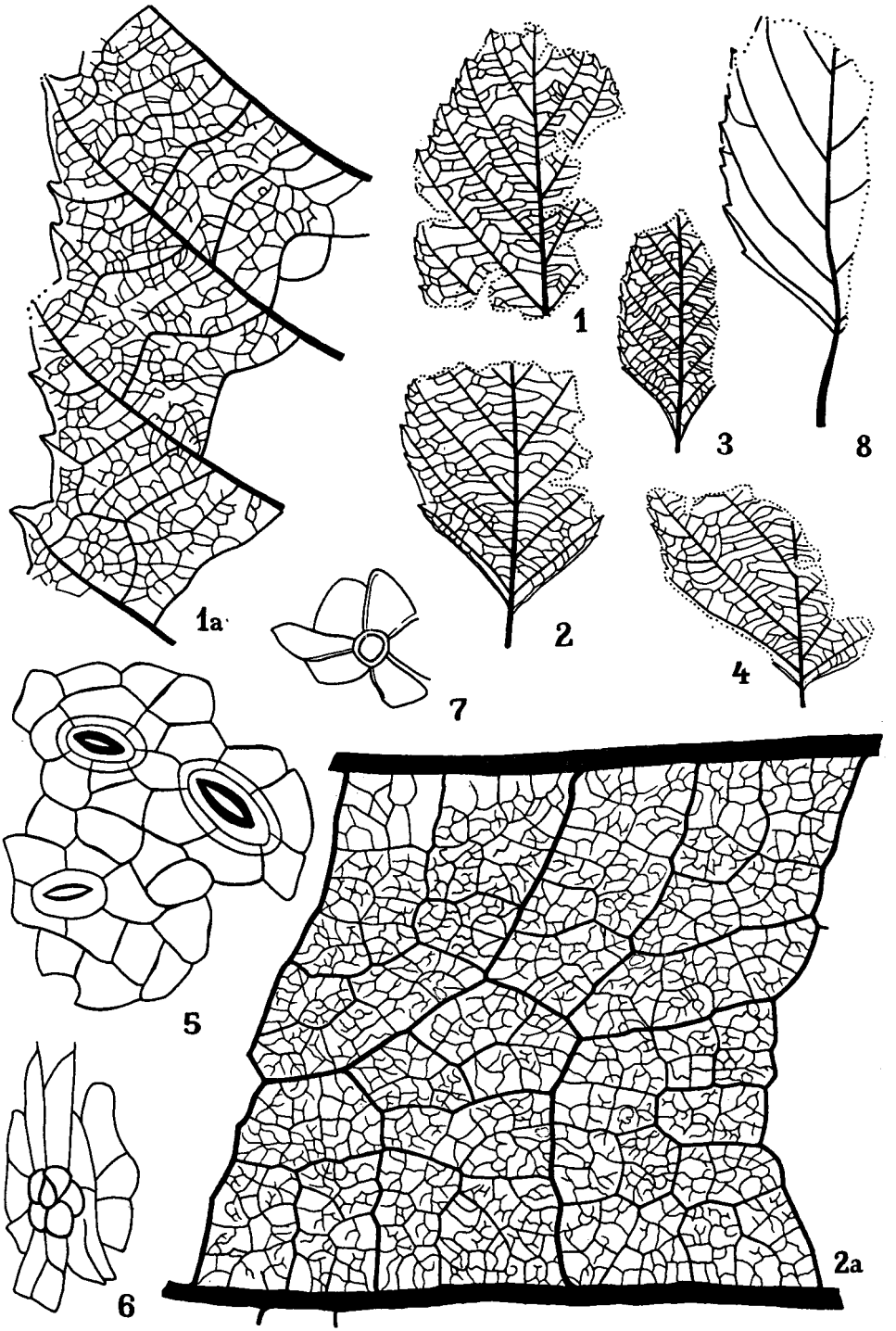


Fig. 6. *Betula plioplatyptera* sp. nov. 1 – holotype, specimen No MZ.VII/67/0/26, x 1; 1 a – enlargement of the leaf margin, x 4; 2 – paratype, specimen No MZ.VII/67/0/24, x 1; 2 a – higher order venation, x 14, drawing by J. Wieser; 3 – specimen No MZ.VII/67/0/56, x 1; 4 – specimen No MZ.VII/67/0/20, x 1; 5 – lower epidermis, stomata, specimen No MZ.VII/67/0/24, x 500; 6 – lower epidermis, multicellular trichome base, specimen No MZ.VII/67/0/24, x 500; 7 – lower epidermis, circular trichome base, specimen No MZ.VII/67/0/56, x 500; 8 – *Betula platyptera* Ettingshausen, twin impression of syntype (Ettingshausen 1872, Pl. 3, fig. 25)

Material. Layer 8/WL.O: Nos. MZ.VII/67/0/ 19, 20, 24, 26, 56; five leaf fragments, including four fragments with preserved bases.

Morphological description. Leaves elliptic or slightly elliptic-ovate, apex missing, base cuneate or decurrent, very slightly asymmetric (Pl. 4, fig. 1, 1a). Dimensions of leaves estimated at 4.0–8.0 x 2.0–4.0 cm; dimensions of the largest preserved leaf fragment being 4.3 x 3.0 cm. Fragments of petiole 0.3–0.9 cm long.

Leaf margins at the base entire within a longer segment, higher up distinctly doubly serrate (Pl. 3, fig. 1a; Fig. 6: 2). Teeth of the first order, entered by secondary veins, much bigger than the secondary teeth (0.8) 1.3–2.0 mm high and 2.3–3.6 mm wide at the base, with acute apex, acute apical angle, apical side acuminate, short, basal side longer than apical, acuminate or concave; (1) 2 (3) teeth of the second order between two adjacent secondaries (0.2) 0.3–0.6 (0.7) mm high and (1.0) 1.5–2.5 (3.5) mm wide at the base, with tooth apex acute, apical angle acute, apical side short, straight or concave, basal side long, straight, concave or acuminate (Fig. 6: 1a). Sinuses between teeth angular.

Venation pinnate, simple craspedodromous. Midvein straight, moderate or stout, gradually tapering toward leaf apex. Secondary veins, presumably 7–9 pairs, branching from midvein at intervals (3) 5–8 (11) mm at an angle of 35–45 (60)°. Secondaries arranged alternately or almost oppositely, basically straight, in the upper part of leaf lamina sometimes slightly arcuate and markedly turned upward just before entering teeth. The lowermost pair of secondary veins, originating supra-basally, running parallelly to leaf base (Pl. 4, fig. 1, 1a); in their final segment, within the serrate margin, branching towards super adjacent vein. Right at leaf base, along its margin, another pair of veins observed, intermediate in thickness between second and third order veins; they disappear in flattened loops of tertiaries. In the lover part of leaf lamina, outer branches of secondary veins entering teeth of second order sometimes observed. In the apical part of leaves short intersecondary veins sporadically found.

Tertiary veins percurrent, irregular, predominantly alternate and forked, sometimes simple; perpendicular or oblique to secondaries, 5–7 (12) per 1 cm of the secondary vein length. Higher order venation partially orthogonal and partially randomly oriented (Fig. 6: 2a). Development of areoles imperfect, arrangement random. Veinlets branched once or few times. Marginal ultimate venation looped.

Anatomical description. Few preserved fragments of the upper cuticle indicating that the upper epidermis is composed of isodiametric or slightly elongate, basically square to hexagonal cells with the longest diagonal fluctuating within limits of (11) 15–24 μm. Straight or rounded anticlinal walls of cells uniformly slightly cutinized, 5–16 (20) μm in length. Cuticle granulate (Pl. 5, fig. 1). Hair bases not found.

The cells of lower epidermis square to hexagonal, subisodiametric or slightly elongated, the longest diagonal (8) 10–19 (25) μm. Anticlinal walls of cells 5–15 (21) μm in length, straight or rounded, slightly uniformly or more strongly and irregularly thickened (Pl. 5, fig. 4). The cells over veins rectangular, elongated 2–7 times, with shorter walls perpendicular or oblique to longer ones.

Stomatal apparatus anomocytic (Pl. 5 fig. 3, 4; Fig. 6: 5). Stomata elliptic or oblong

with length fluctuating within limits (13) 16–23 (26) μm for a single leaf. Guard cells slightly cutinized, their epidermal walls poorly visible. Outer stomatal ledges surrounding spindle-shaped or oblong aperture, more distinct. Aperture size, including the outer stomatal ledges, being (8) 11–16 (20) x 3–5 (8) μm. Frequently found heterostomata 24–35 μm in length, with strongly cutinized outer stomatal ledges (16–22 μm long and 6–11 μm wide) surrounding narrow aperture of 10–20 x 1–3 μm. Sometimes visible delicate cuticular strations perpendicular to aperture. Stomata irregularly distributed in non-venous areas. Stomatal Index 3–5 per cent. The two types of trichome basses indicative of the presence of two types of hairs. Over the veins and in vein angles multicellular (about six-celled) bases found, most probably belonging to glandular hairs (Pl. 5, fig. 2; Fig. 6: 6). Bases usually circular or oblong, with diameter fluctuating within limits 16–27 μm. The other type of trichome bases (Fig. 6: 7) are sporadically found small circular bases about 8 μm in diameter. These bases, probably belonging to unicellular hairs, surrounded by 5–8 trichome-base cells, with thickened poral and partially radial walls.

Comparison. The leaf remains have been assigned to the genus *Betula* based on their morphological features and anatomical structure. They have a cuneate base, typical of birch leaves, distinct characteristic doubly serrate leaf margins, few secondary veins, and relatively sparse and irregular third order venation. These single features are also found in other *Betulaceae*, their combination, however, indicates genus *Betula*. Typically of birch leaves, they also have imperfect areoles and branched veinlets (comp. Wolfe & Wehr 1987).

The following features of epidermal structure confirm that the remains concerned belong to birch: straight or rounded anticlinal cell walls of the upper and lower epidermis, granulate cuticule of the upper side of the leaf, considerable variability of stomata size in one specimen, frequent heterostomata, sometimes with cuticular strations perpendicular to stomatal aperture, and approximately 6-celled bases of glandular hairs. However, stomata are considerably smaller than in most of recent *Betula* species.

The leaves from Ruszów most resemble the fossil species of *Betula platyptera* Ett., reported by Ettingshausen (1872 p. 20, Pl. 3, fig. 25, 34) from the Egerian of Yugoslavia (Sagor). Ettingshausen's description is based on leaves and nutlets. The part of the diagnosis referring to leaves is as follows "foliis longe petiolatis, ovatis, grosse et inaequaliter vel subduplo-serratis, nervatione craspedodroma, nervo primario recto attenuato, nervis secundariis sub angulis 35–40° orientibus paullo arcuatis, inferioribus furcatis, mediis et superioribus simplicibus, tertiariis angulo subrecto exentibus, inter se conjuctis" (Ettingshausen l.c., p. 20).

In the Geologische Bundesanstalt collection in Vienna there is a half of the twin impression of one leaf *B. platyptera* Ett. out of the two illustrated by Ettingshausen (1872, Pl. 3, fig. 25). Comparison of the leaves from Ruszów with the syntype *B. platyptera* Ett. (Fig. 6: 8) shows that they have a number of similar features: the shape of leaf lamina, and leaf base, equally characteristic margin serration, identical pattern of the lowermost secondary veins and similar departure angle of secondaries from midvein. The difference concerns the course and density of secondary veins, which in *Betula pla-*

typtera Ett. are slightly arcuate and run somewhat more sparsely. The results of the comparative analysis, as well as much younger age of the Ruszów flora, decided that the leaves from Ruszów have been described as a new taxon deriving from the Oligocene *Betula platyptera* Ett.

Another fossil species which has leaves similar to *B. plioplatyptera* sp. nov. from Ruszów is *Betula elliptica* Sap. described by Saporta (1867, Pl. 5, fig. 3, 3a) from the Tertiary flora of Bois d'Asson. Its leaves have oblong-elliptic shape, cuneate base, doubly serrato-crenate margin, entire at the base, and few secondary veins with the lowermost pair running almost parallely to leaf base. As compared to leaves from Ruszów, leaves *B. elliptica* Sap. have more acute angles of departure of the secondaries from midvein, and the serration of the leaf margin begins closer to the middle of the base and is more regular. Saporta compared the leaves of *B. elliptica* Sap. with the leaves of recent Himalayan birch *B. jacquemontii* Spach.

Leaves *B. plioplatyptera* sp. nov. from Ruszów differ from *B. subpubescens* Goepp. from Ruszów in that: the shape of their lamina is more elongated, they have different shape and arrangement of teeth at the margins, the course of secondary veins in the lower part of the leaf is more parallel, and third order venation is usually sparser and less regular. The differences in leaf base development are most distinct (compare p. 4, fig. 1, 1a and Pl. 7, fig. 2, 2a). In the higher order venation pattern there are no distinct differences between the two species. In term of anatomical structure slight differences occur in the structure of stomata which in *B. plioplatyptera* have a more elongated shape and usually longer and more marrow outer stomatal ledge aperture.

One of the leaves assigned as *B. subpubescens* Goepp. by Shvareva (1983, Pl. 77, fig. 1; Textfig. 14: 6) from the Middle Miocene flora of Lvov is very similar to *B. plioplatyptera* sp. nov. from Ruszów. It has the same shape of lamina and of leaf base, with identically serrate leaf margins in particular. The only difference with respect to Ruszów leaves is a smaller number of secondary veins.

So far fossil cuticles of *Betula* leaves have been investigated in few cases. The cuticle of *Betula* sp. reported from Rodder Grube bei Brühl (Kräusel & Weyland 1954) differs from the cuticle of Ruszów *Betula* in that it has much bigger stomata (38–57 μm long). The cuticle of *Betula dryadum* Brgt. non Ung. emend. Saporta from the flora of Seifhennersdorf (Mai 1963, Pl. 5, fig. 10, 11) and the cuticle of the LXX type leaf (from Kreuzau) illustrated by Ferguson (1971, Pl. 49, fig. D, E) and assigned by Weyland (1934, Pl. 5, fig. 3) to *Betula brongniartii* Ett. have stomata and the other basic epidermal cells similar in shape and size to those of *B. plioplatyptera* sp. nov. from Ruszów. However, neither heterostomata nor hairs or their bases have been found in those cuticles.

While comparing morphological features of leaves of recent *Betula* species with *B. plioplatyptera* sp. nov. from Ruszów it was stated that they resemble some of the leaves of North American birch *B. papyrifera* Marsh. (Pl. 4, fig. 2, 3), and particularly its form *elongata* Schneider (1906). They have similar type of leaf margin serration, the number and course of the secondary veins and the character of higher order venation. In terms of shape and structure of the leaf base there is some similarity to another recent North-American species – *Betula nigra* L.

Comparative analysis of recent leaf cuticles has shown that *B. papyrifera* Marsh. considerably differs from the fossil species with respect to the features of epidermal structure. The cells of the upper and lower epidermis, stomata. and bases of both hair types are much bigger in the cuticles of recent leaves. There is some similarity of size and shape of stomata and of other epidermal cells in the cuticle of *Betula nigra* L. The cuticle that most resembles *B. plioplatyptera* sp. nov. has been found in the East-Asian birch *B. platyphylla* Sukatschev (Pl. 5, fig. 5).

Their upper and lower epidermal cells, stomata, outer stomatal ledge aperture, and trichome bases are similar in size and shape to those of *B. plioplatyptera* sp. nov. Heterostomata are also frequent. However, the leaves differ with respect to morphological structure.

Occurrence in Poland's fossil floras. Species new to the Tertiary.

Reference herbarial materials:

Betula platyphylla Suc. – North Mongolia, leg. Ikonnikov-Galitzky, det. W. Sukatschev 440 LE; China, Prov. Tancy, leg. det. M. P. Pietrov LE

Betula papyrifera Michx. – Deadwood, Dakota, leg. W. P. Carr, det. P. A. Rydberg 34 LE; Ontario, Canada, coll. L. Jenkins 6512 Herb. Univ. Pragus; Carleton County, Canada, coll. L. Jenkins 16284 W; Caraquet Island, Gloucester County, coll. H. A. Seen 9083 W; Soouth Bay Mounth, Canada, coll. det D. R. Lindsay 3137 WU

Betula nigra L. – Potomac Valley, coll. A. Chase, det. C. Natho 12098 W; Flora Washington D. C. et Vicinity, river flats, coll. E. S. Steele 1725 WU; York Furnace Pa., coll. J. B. Brinton 2386 WU; Illinois, coll. A. Krout WU

Betula subpubescens Goeppert

Pl. 6, fig. 1–4, Pl. 7, fig. 1–4, Pl. 8, fig. 1–5; Fig. 7: 1–13

1855. *Betula subpubescens* Goeppert; Goeppert, p. 11, Pl. 3, fig. 9.

Material. Layer 8/2: Nos. MZ.VII/66/8/ 60, 93, 105; Layer 8/WL.O: Nos. MZ.VII/67/0/ 16, 28, 29, 32, 59, 63, 68, 73; twelve leaf fragments including five with preserved apex and three with preserved base.

Morphological description. Fragments of apparently ovate or elliptic-ovate leaves of presumed dimensions 3.5–5.5 x 2.5–3.5 cm. Leaf apex acute or short acuminate, base cuneate, in one specimen slightly decurrent. Length of preserved fragments of petiole 6.5 and 9.0 cm.

Leaf margins entire at the base, and doubly serrato-dentate higher up (Pl. 6, fig. 2, 2a, 4, 4a; Fig. 7: 2, 8, 9). Primary teeth with the right or acute apical angle and acute, mostly damaged apex. Both sides of primary teeth predominantly acuminate, basal side slightly longer than the apical one; sometimes with a small additional tooth or barely marked convexity. Teeth (0.6) 0.7–1.0 mm high and 1.5–2.5 mm wide at the base. Secondary teeth up to 3 between two adjacent lateral veins, more numerous in lower part of leaf. Tooth apex acute, apical angle acute, less frequently right; apical side straight or acuminate, short; basal side acuminate, straight or convex. Secondary teeth 0.3–0.6 (0.8) mm high, (0.6) 1.0–1.6 (2.2) mm wide at the base (Fig. 7: 1a) Sinuses between teeth angular.

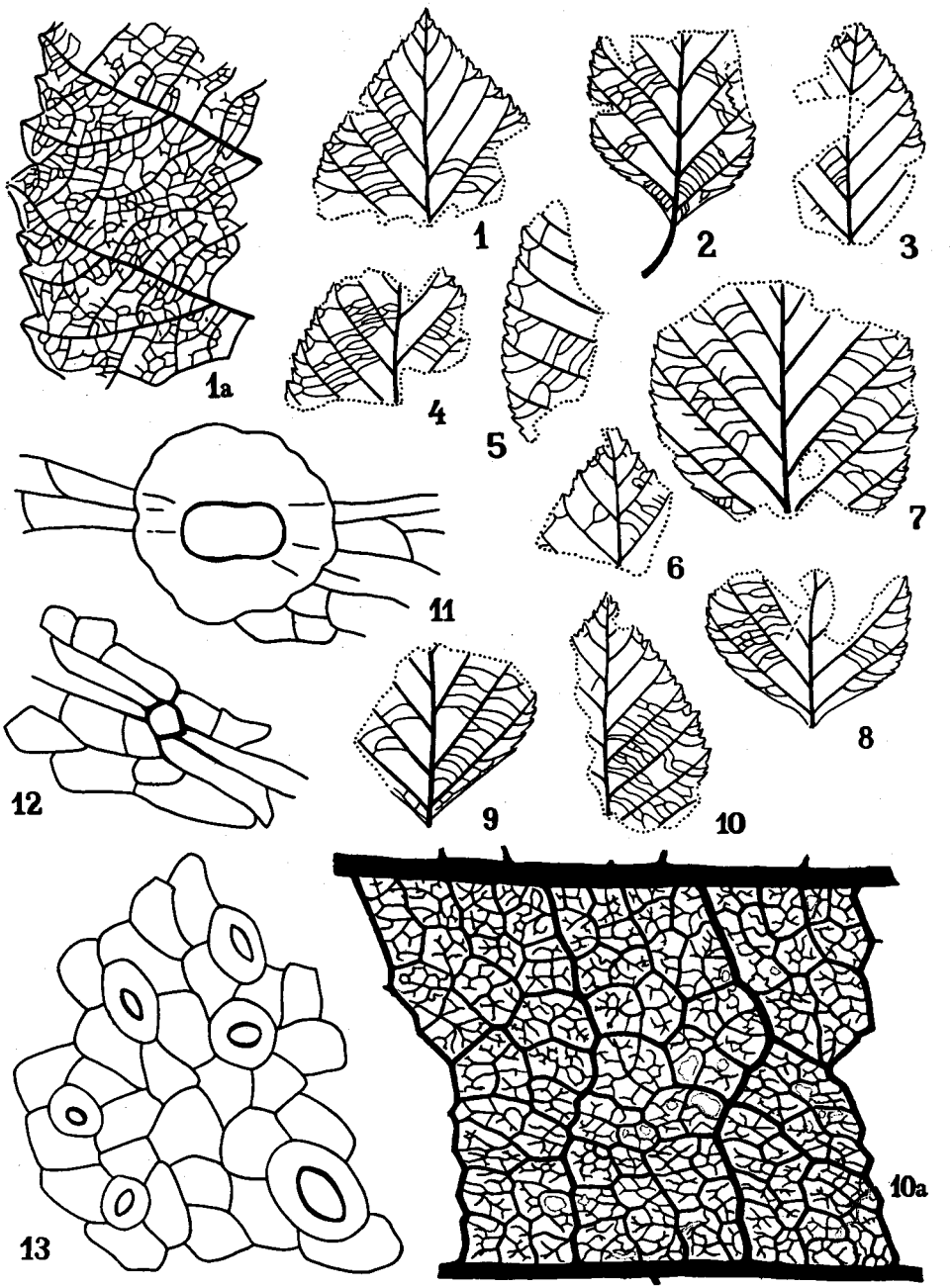


Fig. 7. *Betula subpubescens* Goeppert. 1 – specimen No MZ.VII/67/0/16, x 1; 1 a – enlargement of the leaf margin, x 4; 2 – specimen No MZ.VII/67/0/63, x 1; 3 – specimen No MZ.VII/66/8/93, x 1; 4 – specimen No MZ.VII/67/0/73, x 1; 5 – specimen No MZ.VII/67/0/28, x 1; 6 – specimen No MZ.VII/66/8/105, x 1; 7 – specimen No MZ.VII/67/0/29, x 1; 8 – specimen No MZ.VII/67/0/68, x 1; 9 – specimen No MZ.VII/67/0/32, x 1; 10 – specimen No MZ.VII/67/0/59, x 1; 10 a – higher order venation, x 14, drawing by J. Wieser; 11 – lower epidermis, peltate gland, specimen No MZ.VII/67/0/68, x 500; 12 – lower epidermis, circular trichome base, specimen No MZ.VII/67/0/68, x 500; 13 – lower epidermis, stomata, specimen No MZ.VII/67/0/68, x 500

Venation pinnate, simple craspedodromous. Midvein moderate, straight, sometimes sinuous with respect to branching points of secondary veins. Secondaries (about 8 pairs) usually alternating, in the lower part of leaf lamina almost opposite, basically straight, just before entering teeth vein endings abruptly deflecting upward; branching from the midvein at intervals (2.5) 4–6 (8) mm; in the upper part of a leaf running almost parallely to each other, in the lower part – the intervals between two adjacent secondary veins being wider near leaf margin than where they branch from the midvein; forming with the midvein an angle of 30–50 (55)° which decreases toward leaf apex. The lowermost pair of secondary veins originating supra-basally run almost parallely to leaf base (Pl. 7, fig. 2, 2a). Along margins of leaf base a pair of thin veins visible, forming loops with tertiary veins. Short intersecondary veins sporadically occurring in apical part of leaves. Outer branches branching from secondary veins, up to 5 per one lateral vein, their number increasing toward leaf base; entering teeth of second order. From each outer branch a fine vein running to the sinus below the tooth.

Tertiary veins percurrent, relatively regular, simple or forked more or less half-way between adjacent secondaries, branching from the secondary veins at right angle or obliquely, (5) 8–12 per 1 cm of the secondary vein length. Higher order venation orthogonal to randomly oriented (Fig. 7: 10a). Areole imperfect, arrangement random. Veinlets branched several times. Marginal ultimate venation looped.

Anatomical description. Upper epidermis (Pl. 8, fig. 1). Cells isodiametric or slightly elongated, square to hexagonal, their longest diagonal within limits (11) 16–23 (30) μm. Anticlinal walls of cells straight or rounded, slightly uniformly cutinized, 5–16 (25) μm in length. Other epidermal formations invisible. Lower epidermis. Cells square to hexagonal, subisodiametric or slightly elongated with their longest diagonal 11–25 μm. Anticlinal walls of cells usually slightly uniformly cutinized, straight or rounded, 5–12 (21) μm in length. Rectangular cells elongated several times, with shorter walls perpendicular or oblique to longer ones, occurring over veins. Stomatal apparatus anomocytic (Pl. 8, fig. 4; Fig. 7: 13). Stomata circular or elliptic, of various sizes, their dimensions fluctuating within limits of (13) 16–21 (23) x (13) 15–19 (22) μm. Epidermal walls of guard-cells thin, often poorly visible. Thickened outer stomatal ledges surrounding elliptic, sometimes almost circular, and rarely narrow spindle-shaped outer stomatal ledge aperture. Aperture size, together with outer stomatal ledges, fluctuating within limits of (6) 8–12 (16) x (3) 5–8 (10) μm. Heterostomata 26–36 μm in length and 20–30 μm in width with outer stomatal ledges 16–26 x 10–12 μm often found (Pl. 8, fig. 5). Sometimes heterostomata differing from normal stomata only in size. However, their outer stomatal ledges often strongly thickened, distorted and almost completely closing the outer stomatal ledge aperture being then 13–16 x 2 μm. Heterostomata usually surrounded by 6–8 radially distributed subsidiary cells similar in size to the normal epidermal cells. Sometimes observed cuticular strations perpendicular to the pore. Stomata irregularly distributed in non-venous areas. Stomatal Index 3–6 per cent.

Peltate glands (Fig. 7: 11), of about six-celled circular or oblong bases (Pl. 8, fig. 3) with dimensions within limits 24–26 x 13–24 μm, usually distributed over the veins on the lower epidermis. Discs of glands sometimes preserved, 45–57 μm in diameter (Pl. 8,

fig. 2). In addition to peltate glands other hairs, probably unicellular, occurred; of these, only circular, strongly cutinized bases 6–11 μm in diameter preserved; occurring sporadically over veins; with radial walls of trichome-base cells usually thickened (Fig. 7: 12).

Comparison. As far as morphological features are concerned, the described remains are closest to *Betula subpubescens* Goepp. from Sośnica (Goeppert 1855). In his revision of Betulaceae remains from this locality Reimann (1919) included into the synonyms of *B. subpubescens* Goepp. also other fossil species from Sośnica, namely *Betula dryadum* Brongn., *B. crenata* Goepp., *B. subovalis* Goepp. and *Alnus similis* Goepp. According to Zastawniak (oral communication), only *B. dryadum* Brongn., illustrated by Goeppert (1855, Pl. 3, fig. 1), is a synonym of *B. subpubescens* Goepp.

Two out of three leaf remains which were described by Ettinghausen (1851, Pl. 1, figs 15, 16) as *Betula prisca* Ett. are similar to *Betula subpubescens* Goepp. These two leaf fragments come from the Arsenal locality in Vienna and today can be seen in the Geologische Bundesanstalt collection in Vienna. The third leaf illustrated by Ettingshausen as *B. prisca* (Ettingshausen l.c., Pl. 1, fig. 17) comes from another fossil flora (Bilina, Czecho-Slovakia). It is fully preserved and the author's diagnosis of *B. prisca* species was based on it. That specimen, which – judging from drawings – is different from the other two remains from Arsenal, has been lost[1].

A detailed analysis of morphological structure of the leaves from Arsenal showed that those remains could most probably be assigned to *Betula subpubescens* Goepp. Although the leaves from Arsenal have a more elongated shape and some inconsistencies in the type of venation, considerable variability of morphological features of *Betula subpubescens* Goepp. remains from Ruszów, along with identical features of anatomical structure of their epidermis, justify the above hypothesis.

The leaves of *B. subpubescens* Goepp. have been known since the Middle Oligocene in Europe (flora from Seifhennesdorf, Mai 1963, Walther 1964). However, they were most numerous in the Neogene floras of this area.

Betula subpubescens Goepp. has often been compared with the recent *B. pubescens* Ehrh. (= *B. alba* Roth.), sometimes also with the East-Asian *B. davurica* Pall. and the Himalayan species *B. bhojpathra* Wall. (= *B. utilis* D. Don.). According to Němejc (1949), the leaves of *B. subpubescens* Goepp. are similar not only to *B. pubescens* Ehrh. but also to *B. verrucosa* Ehrh. (= *B. pendula* Roth.).

In terms of morphological structure the leaves of *Betula subpubescens* Goepp. from Ruszów correspond primarily to the leaves of *B. pubescens* Ehrh., birch which grows today in humid forests and on lake and river banks, on the area extending from Central and Atlantic Europe to the Caucasus and Siberia (Sokolov 1951). There is also a similarity to East Asian birch-trees (*Betula ermanii* Cham., *B. davurica* Pall. and *B. schmidtii* Regel) as far as the shape of leaf lamina, leaf margin development and secondary venation character – particularly the number of secondary veins – are concerned (*B.*

[1] Typification of the *Betula prisca Ett.* is discussed in separate paper (Hummel 1991).

ermanii 6–9 (19), *B. davurica* 7–9, *B. schmidtii* 7–10, whereas *B. pubescens* has 5–7).

Based on the cuticle comparison of recent species of birch and *B. subpubescens* Goepp. from Ruszów, it was stated that most similarity occurs in the cuticle of *B. schmidtii* Regel (Pl. 9, fig. 1, 2), birch which today grows on dry and rocky mountain slopes in East Asia. They have similar size and shape of outer stomatal ledge aperture and of stomata themselves, similar size and structure of bases and discs of glandular hair, and similar size and shape of upper epidermal cells. However, the leaves of the recent species have denser glandular hairs and somewhat bigger cells of lower epidermis. Besides, the leaves of *B. utilis* D. Don. (= *B. bhojpathra* Wall.) and the leaves of North American *B. lenta* L. have a similar type of cuticle, but with bigger stomata.

Occurrence in Poland's fossil floras. Sośnica (Goeppert 1855), Brzeg Dolny (Reimann 1919), Snicz (Biernat 1964), Młyny (Zastawniak 1980).

Reference herbarial materials:

Betula davurica Pall. – N. China, coll. Wei Chang 2760 WU; Korea, coll. O. Warburg WU

Betula ermanii Cham. – Japan, Prov. Ienano, leg. det. Maximowitsh 1864 LE; Yumoto, Japan 5190 W; Hokkaido, Prov. Tokachi, coll. Hideo Tabata 502 LE; China, coll. F. N. Meyer LE; Japan near Hakodate, coll. Dr. Albrecht LE

Betula lenta L. – Pensylvania, coll. J. B. Brinton 2886 WU; North Carolina 1817 WU; Delavere, coll. A. Krout WU

Betula pubescens Ehrh. – Zubrza near Lwów, coll. R. Lajos 23735 W; Berg near Fischau, coll. F. Wimmer 16421 W; Freiberg (Hessen), coll.

C. Baenitz 13924 W; Hungary, Háromszék coll. S. Javorka 2805 WU; Sweden, coll. F. Vierhapper 2935 WU; Osobowice near Wrocław, leg. J. Sibilski 04553 W

Betula schmidtii Regel – Japan, Tochigi, near the Kobu Shrine, leg. H. Kanai 6139 LE

Betula utilis D. Don. – NW Himalayas, coll. J. F. Duthie 1832 WU; B. bhojpaltra Wall. North-Western India, leg. det. J. Duthie 1240 LE; China, Prov. Setschwan, coll. Handel-Mazzetti 2730 WU

Betula sp.

Pl. 9, fig. 3–5; Fig. 8: 1, 2

Material. Layer 8/WL.O: Nos MZ.VII/67/0/ 41, 50; one small leaf with preserved

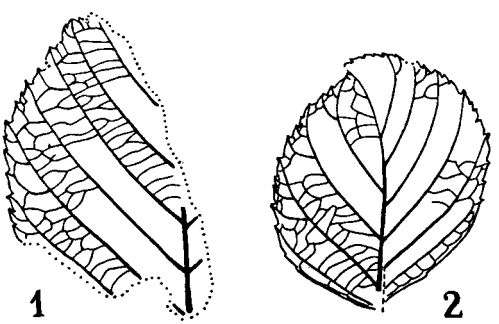


Fig. 8. *Betula* sp. 1 – specimen No MZ.VII/67/0/50, x 1; 2 – specimen No MZ.VII/67/0/41, x 1

apex and base, one fragment of a larger leaf.

Morphological description. One of specimens being wide elliptic-ovate leaf of dimensions 3.5 x 2.9 cm; leaf apex disfigured, base widely cuneate. The other specimen being a fragment of the middle part of a larger leaf about 5.0 cm wide.

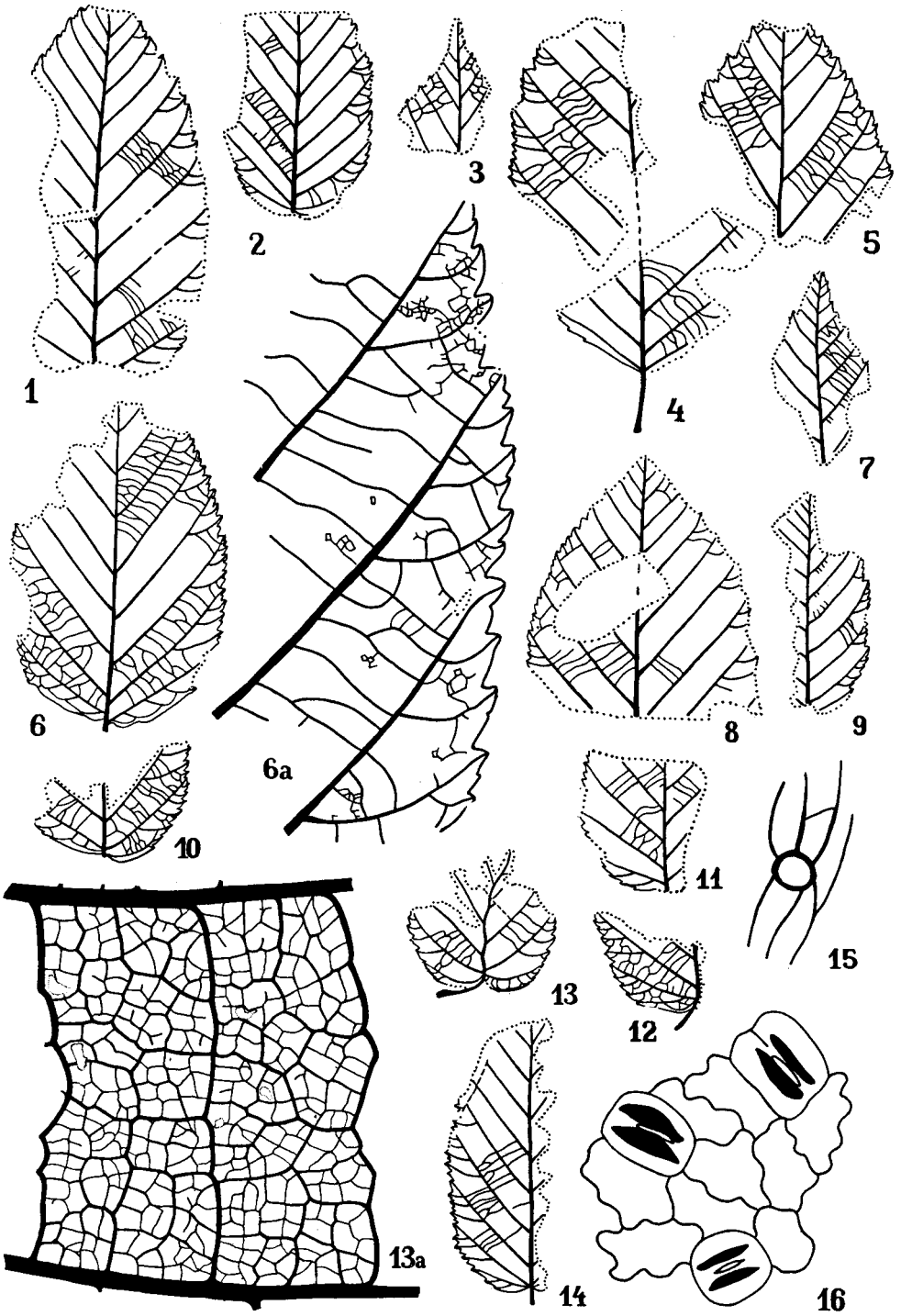
The margin of the completely preserved leaf at the base entire; higher up margins of both leaves doubly serrate. First order teeth 1.0–1.5 mm high and 2.0–3.0 mm wide at the base; apex acute, apical angle usually acute, apical side acuminate or straight, basal sideacuminate, longer than apical. Two to three secondary teeth between two adjacent lateral veins 0.3–0.5 mm high and 1.0–3.0 mm wide at the base; their apex and apical angle acute, apical side straight or concave, short, basal side acuminate or convex, long. Sinuses between teeth angular.

Venation pinnate, simple craspedodromous. Primary vein moderately thick. Secondary veins (about 7 pairs in completely preserved leaf) alternate or almost opposite, slightly curved, branching from midvein at intervals 3–6 mm at an angle of 40–60°, increasing toward the leaf base. The lowermost secondaries running parallelly to leaf base. Just at the leaf base a pair of thin veins observed, disappearing in flattened loops of tertiaries. In the basal part of leaf outer branches of secondary veins visible, entering secondary teeth. No intersecondary veins observed.

Tertiary veins percurrent, forked, sometimes simple, 5–9 per 1 cm of secondary vein length, with a more regular course in the larger leaf. Higher order venation usually randomly oriented. Areoles imperfect. Marginal ultimate venation poorly visible.

Anatomical description. Cells of upper epidermis polygonal, isodiametric or slightly elongated, 11–24 μm in the longest diagonal. Anticlinal walls of cells straight or rounded, slightly uniformly cutinized, 5–11 (19) μm in length. Hair bases not found. Cells of lower epidermis square to hexagonal, usually isodiametric, with the longest diagonal fluctuating within limits 11–16 (20) μm. Anticlinal walls of cells uniformly cutinized, straight or rounded, 5–16 μm in length. Stomatal apparatus anomocytic (Pl. 9, fig. 5). Stomata oblong or elliptic with epidermal walls of guard cells poorly visible and marked outer stomatal ledges surrounding spindle-shaped outer stomatal ledge aperture. Length of stomata 16–20 (23) μm, dimensions of aperture – including outer stomatal ledges- varying from 10 to 13 (16) μm in length and from 3 to 5 (6) μm in width. Heterostomata of about 28 x 18 μm sporadically visible, their outer stomatal ledges being 19 x 8 μm. Multicellular bases of glandular hairs, approx. 21 x 16 μm, sometimes visible.

Fig. 9. *Carpinus grandis* Unger sensu Heer. 1 – specimen No MZ.VII/66/8/84, x 1; 2 – specimen No MZ.VII/66/8/149, x 1; 3 – specimen No MZ.VII/66/8/230, x 1; 4 – specimen No MZ.VII/66/8/172, x 1; 5 – specimen No MZ.VII/67/0/12, x 1; 6 – specimen No MZ.VII/67/I/68, x 1; 6a – enlargement of the leaf margin, x 4; 7 – specimen No MZ.VII/66/8/355, x 1; 8 – specimen No MZ.VII/66/8/257, x 1; 9 – specimen No MZ.VII/66/8/94, x 1; 10 – specimen No MZ.VII/67/II/14, x 1; 11 – specimen No MZ.VII/66/8/240, x 1; 12 – specimen No MZ.VII/67/0/30, x 1; 13 – specimen No MZ.VII/67/I/37, x 1; 13a – higher order venation, x 14, drawing by J. Wieser; 14 – specimen No MZ.VII/67/0/4, x 1; 15 – upper epidermis, unicellular trichome base, specimen No MZ.VII/67/0/4, x 500; 16 – lower epidermis, stomata, specimen No MZ.VII/67/0/4, x 500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Comparison. Morphological and anatomical structure of both remains indicate that they belong to genus *Betula*. Leaf base and margins, some features of secondary and higher order venation, and anatomical structure show some similarity to *Betula plioplatyptera* Hummel from Ruszów. These specimens have not been assigned as the latter species due to lamina shape of one of them (Pl. 9, fig. 3), and to denser secondary venation of the other remain (Pl. 9, fig. 4). However, its relation to that fossil taxon cannot be excluded.

Carpinus grandis Unger emend. Heer

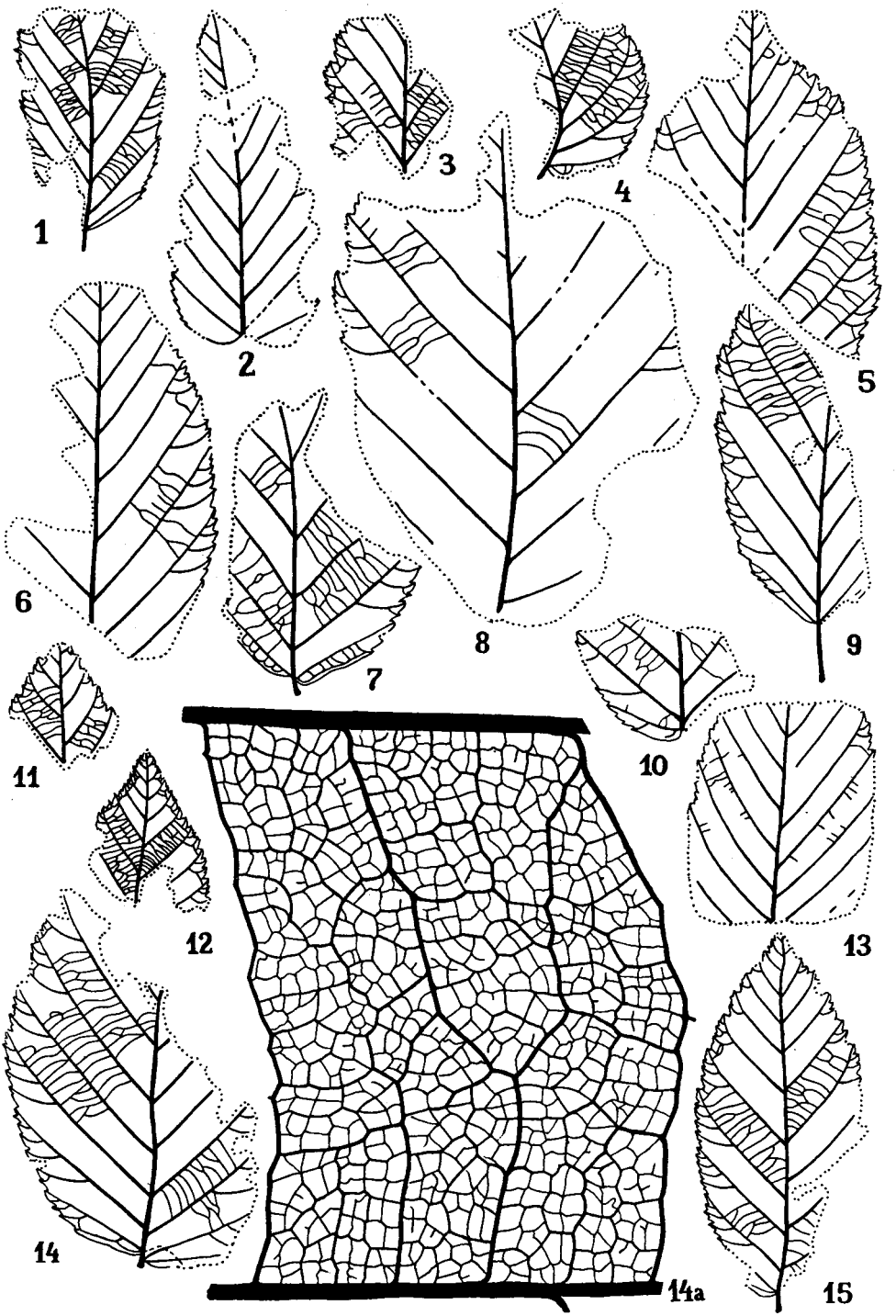
Pl. 10, fig. 1–13; Pl. 11, fig. 1–8; Pl. 12, fig. 1–5; Pl. 13, fig. 1, 2; Fig. 9–11

1850. *Carpinus grandis* Ung.; Unger, p. 408
1852. *Carpinus grandis* Ung.; Unger, p. 39, Pl. 20, fig. 4, 5 (non fig. 2, 3)
1856. *Carpinus grandis* Ung.; Heer, Pl. 71, fig. 19 b, c–e; Pl. 72, fig. 2–11, 14, 16–17, 19–20, 22–24 (non fig. 18, 21); Pl. 73, fig. 2–4.

Material. Layer 8/1: Nos. MZ.VII/66/8/ 3, 6, 8, 9, 10, 16, 19; layer 8/2: Nos. MZ.VII/66/8/ 72, 73, 78, 79 a, b, 80, 84, 86, 94, 107, 141, 149, 172, 175, 181, 183, 186, 188, 190, 193, 201, 202, 207, 228, 230, 236, 239, 240, 244, 256a, b, 257, 258, 264, 280, 281, 282, 286; layer 8/3: Nos. MZ.VII/66/8/ 354, 355; layer 8/WL.O: Nos. MZ.VII/67/0/ 2, 4, 9, 12, 30, 35, 37, 45, 48, 49, 57, 66, 90; layer 8/WL.I: Nos. MZ.VII/67/I/ 2, 22, 28, 29, 30, 33, 37, 64, 68, 69; layer 8/WL. II: Nos. MZ.VII/67/II/ 14, 22; seventy leaf specimens, including seven almost complete leaves, two with twin impressions, eleven with preserved leaf apex, and twenty-four with preserved base.

Morphological description. Leaves oblong, less frequently elliptic to elliptic-ovate, of dimensions within (5.0) 4.0–7.0 (10.0) x (1.6) 2.0–3.5 (5.0) cm. Leaf apex acute or acuminate, base cuneate to cordate, often slightly asymmetric. Preserved fragments of leaf petiole reach 0.9 cm. Leaf margins doubly serrate, sometimes slightly emarginate, at the base entire. Teeth of the first order in which secondary veins terminate with apical angle right or acute, apex acute, often damaged, 0.5–1.0 (1.5) mm high and 1.0–2.2 (2.5) mm wide at the base; apical and basal sides usually acuminate; basal sides for the most part slightly longer than the apical ones, frequently provided with a small additional tooth or convexity; sometimes additional tooth observed also on apical side. Teeth of second order 1–4 (5) between two adjacent secondaries (more numerous toward leaf base), (0.2) 0.4–0.8 mm high and (0.8) 1.3–2.5 (3.2) mm wide at the base; apex acute, apical angle right, sometimes acute, apical side usually straight, short; basal side acuminate, straight or convex, longer than apical, often provided with a small addi-

Fig. 10. *Carpinus grandis* Unger emend. Heer. 1 – specimen No MZ.VII/67/0/57, x 1; 2 – specimen No MZ.VII/66/8/258, x 1; 3 – specimen No MZ.VII/67/I/29, x 1; 4 – specimen No MZ.VII/67/I/28, x 1; 5 – specimen No MZ.VII/66/8/201, x 1; 6 – specimen No MZ.VII/66/8/236, x 1; 7 – specimen No MZ.VII/67/0/48, x 1; 8 – specimen No MZ.VII/66/8/190, x 1; 9 – specimen No MZ.VII/67/0/9, x 1; 10 – specimen No MZ.VII/66/8/141, x 1; 11 – specimen No MZ.VII/67/I/30, x 1; 12 – specimen No MZ.VII/67/0/66, x 1; 13 – specimen No MZ.VII/66/8/16, x 1; 14 – specimen No MZ.VII/67/I/2, x 1; 14 a – higher order venation, x 14, drawing by J. Wieser; 15 – specimen No MZ.VII/67/I/64, x 1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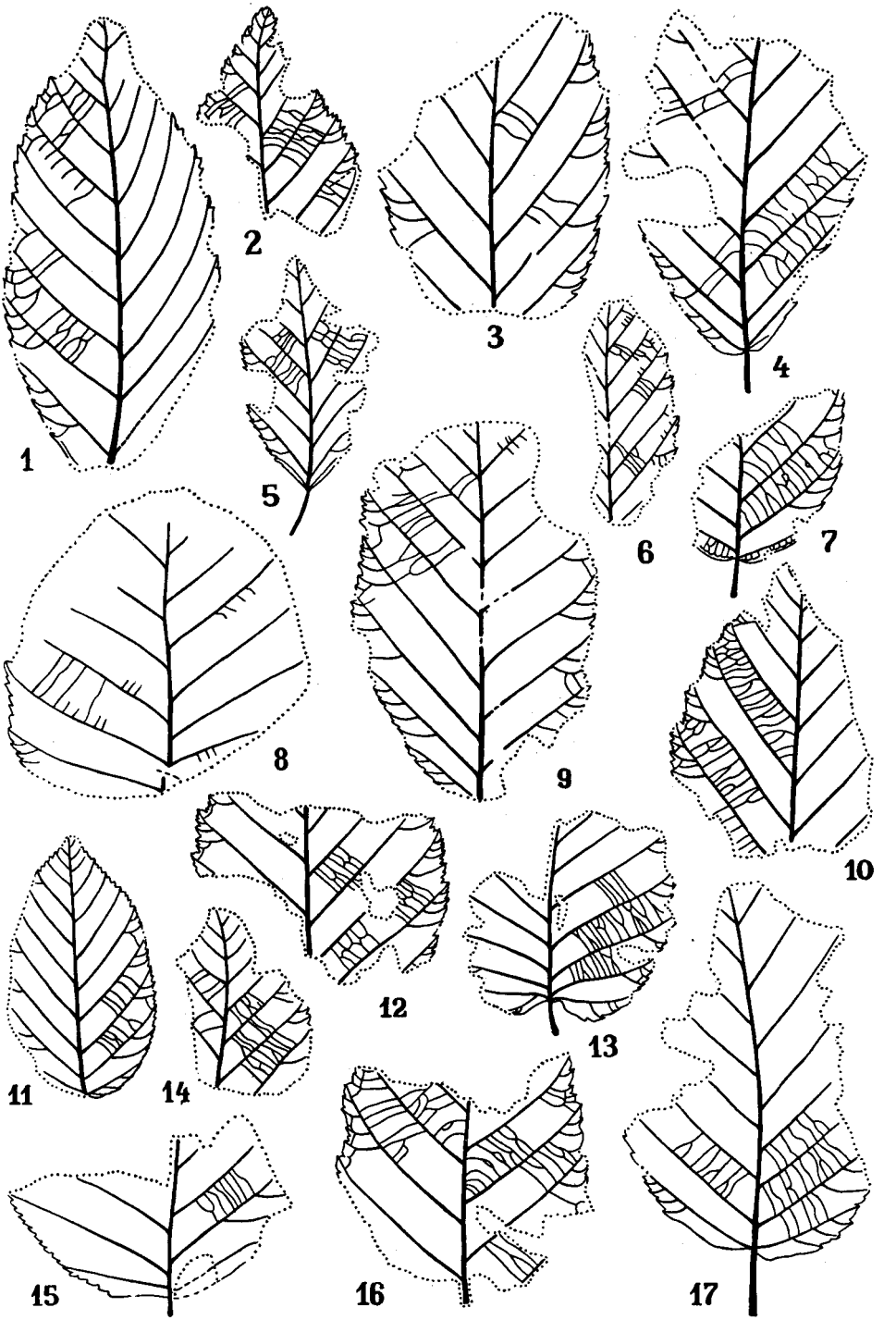
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tional tooth or convexity (Fig. 9: 6a). Sinuses between teeth angular.

Venation pinnate, simple craspedodromous. Primary vein moderately thick, usually straight. Secondary veins straight, sometimes slightly upturned before entering the teeth, predominantly parallel to each other, alternate to subopposite. About 10 to 12 pairs of secondaries diverging from midvein at intervals (1.5) 4–8 (11) mm at an angle of (30) 35° to 50 (60)°, usually decreasing toward leaf apex. Basal veins usually slightly thinner then the other secondaries, diverging at 45–75 (85)°, often running subparallelly to the margin of leaf base; in case of cordate base sometimes diverging from midvein at an obtuse angle and strongly curving parallelly to the leaf margin (Pl. 10, fig. 6, 11, 11a). Right at the entire margin of leaf base, veins originating from exmedial side of secondaries form more or less flat loops or terminate in a fine vein. Outer branches of lateral veins predominantly relatively thin, 1–4 (5) per one secondary vein (more numerous at the leaf base). Intersecondary veins small, occurring sporadically in the area of leaf apex. Tertiary veins percurrent, relatively thin and regular, simple or forked about halfway between two adjacent secondaries, perpendicular or slightly oblique to them, from 8 to 14 (16) per 1 cm of the secondary vein length. Higher order venation thin, course orthogonal (Fig. 9: 13a, Fig. 10: 14a). Areoles well developed, arrangement of areoles oriented. Veinlets none or simple. Marginal ultimate venation looped.

Anatomical description. Anatomical microscopic slides of 38 leaf specimens, coming mostly from leaf-layers, have been studied. Upper epidermis composed of polygonal, isodiametric or slightly elongated cells with their longest diagonal being (16) 22–32 (39) μm. Anticlinal walls of cells straight, rounded or undulate (Pl. 12, fig. 1, 2); slightly, uniformly cutinized; 6–20 (25) μm in length if cell walls are straight or rounded. Only one unicellular small trichome base of 13 x 10 μm seen near the vein. Trichome-base cells with thickened poral and radial walls (Fig. 9: 15). The cells of lower epidermis polygonal, isodiametric or slightly elongated with the longest diagonal fluctuating within limits (11) 20–25 (33) μm. Anticlinal walls of cells usually uniformly cutinized, strongly undulate, sometimes straight or rounded – then 6–16 (22) μm in length.

Stomatal apparatus anomocytic (Fig. 9: 16). Stomata irregularly distributed in nonvenous areas, wide oblong, subrectangular or circular, sometimes their width exceeding their length (Pl. 12, fig. 3–5). Epidermal walls of guard cells only slightly cutinized, therefore poorly visible. Clearly marked wide, rounded or wing-shaped thickenings of stomatal ledges on both sides of narrow, elongated pore. Dimensions of stomata vary from 15 to 24 (27) μm in length and from 13 to 19 (22) μm in width, the length of pore being (5) 8–13 μm. Over the veins unicellular, sometimes bicellular bases of glandular

←

Fig. 11. *Carpinus grandis* Unger emend. Heer, natural size. 1 – specimen No MZ.VII/66/8/80; 2 – specimen No MZ.VII/67/0/45; 3 – specimen No MZ.VII/66/8/86; 4 – specimen No MZ.VII/66/8/193; 5 – specimen No MZ.VII/67/0/35; 6 – specimen No MZ.VII/66/8/8; 7 – specimen No MZ.VII/67/I/33; 8 – specimen No MZ.VII/66/8/9; 9 – specimen No MZ.VII/66/8/183; 10 – specimen No MZ.VII/67/0/49; 11 – specimen No MZ.VII/66/8/79 b; 12 – specimen No MZ.VII/67/0/37, 13 – specimen No MZ.VII/67/0/90,; 14 – specimen No MZ.VII/66/8/107; 15 – specimen No MZ.VII/66/8/264; 16 – specimen No MZ.VII/67/II/22; 17 – specimen No MZ.VII/66/8/202

or non-glandular hairs sporadically visible (Pl. 13, fig. 2). Dimensions of bases 10–16 x 10 μm, poral and radial walls of trichome-base cells usually thickened. In one case a glandular hair preserved, its base being 24 x 20 μm and its ellipsoidal head - 36 x 22 μm (Pl. 13, fig. 1).

Comparison. A dozen or so *Carpinus* species from the European Tertiary are known, described primarily on the basis of fossil nuts and involucres. Leaf remains are usually assigned to one fossil species, *Carpinus grandis* Ung. It is probably a comprehensive species which could include various fossil species, but their differentiation based on leaf fragments is not possible. Within the remains of species occurring in the Oehningen flora, Heer (1856) distinguished eight different leaf forms; he emphasized the fact that they account for the variability limits of one species. Also, there is a strong resemblance among leaves of various recent *Carpinus* species, while on the other hand there is a great diversity of leaf forms within one species (Heer 1856, Andrenászky 1959, Mai & Walther 1978).

With respect to morphological features, leaf remains of *Carpinus grandis* Ung. emend. Heer from Ruszów are very similar to the leaves of recent *Carpinus betulus* L. and *Carpinus caucasica* Grossh. The leaves of the latter species are identical in shape and size with leaves of *C. betulus* L.

Mai & Walther (1978) pointed out that the leaves of *Carpinus grandis* Ung. from the Oligocene localities constitute an intermediate form between the species from the recent section of *Distegocarpus* (Sieb. et Zucc.) Sarg. which, according to Schneider (1906), have 14–25 pairs of secondary veins, or according to Krüssmann (1976), 20–34 pairs of secondary veins, and the species from the section *Eucarpinus* Sarg. which have 7–15 pairs of secondaries. *Carpinus grandis* Ung. emend. Heer leaves from the Ruszów Pliocene have 10–12 pairs of secondary veins and are thus closer to the recent species of *Eucarpinus* Sarg. section.

It is worth noticing that the hornbeam involucres from Ruszów are closer first of all to the involucres of recent *Carpinus caucasica* Grossh. They are smaller than the involucres of *C. betulus* L.

It was stated, based on the comparative studies of epidermal structure features in various leaves of recent *Carpinus* species conducted by this author, that the Ruszów leaves are closest to *Carpinus betulus* L. and to *C. caucasica* Grossh. both of which have very similar cuticles.

Comparing features of the epidermis structure in *Carpinus* leaves from Ruszów with the data presented by Mai & Walther (1978, Table 3, 4), concerning epidermal structure of *Carpinus grandis* Ung. emend. Heer from Oligocene and Miocene localities in Central Europe and epidermal structure of recent *Carpinus* species, one can state that the epidermis features of *Carpinus* leaves from Ruszów are intermediate between the *Carpinus grandis* Ung. from Middle Miocene and the recent *Carpinus betulus* L. It is particularly evident from undulation of the anticlinal cell walls of upper and lower epidermis, and from the size of stomata.

Fossil remains of hornbean, compared with the recent *Carpinus caucasica* Grossh., are known as *Carpinus betulus* L. fossilis from the fossil floras of Kolkhis from the

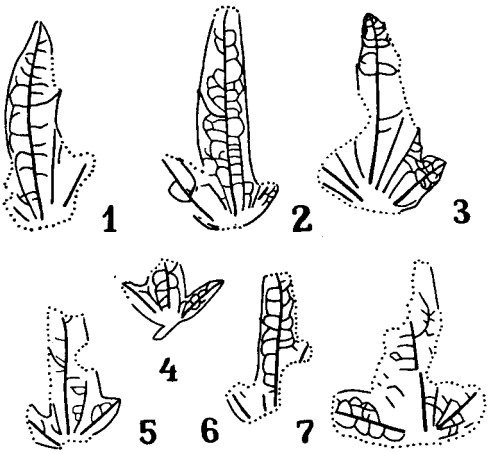

Fig. 12. *Carpinus grandis* Unger sensu Berger, involucres, natural size. 1 – specimen No MZ.VII/66/8/167; 2 – specimen No MZ.VII/66/8/191; 3 – specimen No MZ.VII/66/8/246 a; 4 – specimen No MZ.VII/67/0/83; 5 – specimen No MZ.VII/66/8/259 a; 6 – specimen No MZ.VII/66/8/220; 7 – specimen No MZ.VII/66/8/265

period of Pliocene to Pleistocene (Kolakovsky 1980).

Today *Carpinus betulus* L. grows in Europe on the area extending from South-West France to the European part of the Soviet Union. In the mountains it occurs as high as 800 m above sea level. *Carpinus caucasica* Grossh. is found today in the Caucasus, the Crimea, in the northern part of Asia Minor and in North Iran; in the mountains it grows as high as 2,000 m above sea level (Sokolov 1951).

Occurrence in Poland's fossil floras. Sośnica (Goeppert 1855, Reimann 1919, Łańcucka-Środoniowa et al. 1981), Rozewie (Heer 1869b), Kokoszyce, Zielona Góra, Trzebnica, Brzeg Dolny, Domaradz, Stróża, Wróblin, Chroślice (Reimann 1919), Pierusza, Parowa (Krausel 1920), Chodzież (Zabłocki 1924), Dobrzyń (Kownas 1956), Swoszowice (Iliinskaya 1964).

Reference herbarial materials.

Carpinus americana Michx. – Carolina, det. H. Winkl. 154 LE

Carpinus betulus L. – N. O. Kreuzburg, reg. Semmering, coll. R. Leonhardt 3144 WU; Istria, reg. Monte Maggiore, coll. A. Grinzberger 3088 WU; Lower Austria, coll. Fr. Wettstein WU; Poland: Hajnówka, Mużaków, Prószków near Opole, leg. det H. Czeczott WA ME; Poland, Wyszków, leg. det. A. Hummel WA ME

Carpinus caroliniana Walt. – New Orlean, leg. T. Drummond, det. H. Winkler 142 LE

Carpinus caucasica Grossh. – Azerbaijan, leg. Bobrow LE; Kusary, Azerbaijan SSR, leg. Nowruzowa LE; Georgian SSR, LE; Caucasus near Rica Lake leg. A. Hummel WA ME; Suchumi, leg. A. Hummel WA ME;

Carpinus japonica Blume – China, 6135 LE

Carpinus orientalis Mill. – Yugoslavia, leg. det. E. K. Horwood 23 LE; West Caucasus, leg. A. I. Leskow LE; Baku, leg. Alekseenko LE

Carpinus tschonoskii Maxim. – China, 46520 LE

Carpinus turczaninowii Hance – China LE

Carpinus laxifolia Bl. – China 424 LE

Carpinus grandis Unger sensu Berger

Pl. 13, fig. 4–6; Fig. 12

1850. *Carpinus grandis* Unger; p. 408
1953. *Carpinus grandis* Unger sensu Berger; Berger, p. 14, Abb. 5 A–G

Material. Layer 8/1: No MZ.VII/66/8/ 26; layer 8/2: Nos. MZ.VII/66/8/ 52, 96, 107, 146, 167, 191, 220, 246a, b, 256b, 259a, b, 265; layer 8/WL.O: No MZ.VII/67/0/ 83; thirteen fragments of involucres including two with twin impressions.

Morphological description. Involucres three-lobate. Central lobe long and narrow, gradually tapering to rounded apex, frequently slightly curved and asymmetric. Free section of central lobe of dimensions 2.0–2.5 x (0.5)–0.7 cm. Sometimes central lobe wider at the base, about 2.2 cm wide, asymmetrical (Fig. 12: 7). Lateral lobes usually of unequal size, with acute or slightly rounded apex, free sections of lobes 0.3–0.7 x 0.3–0.6 cm long. Margins of lobes along longer segments entire with sporadically occurring teeth. Three primary veins and several thin, basal secondary veins originating at the base of the involucre. The primary veins diverging toward the lobes. One pair of the central lobe secondary veins usually running along a longer segment of midvein and joining, often asymmetrically, superadjacent secondary veins. The other basal secondary veins, joining in the loops with other secondaries or sporadically terminating in teeth of the central lobe (Fig. 12: 3). The upper secondary veins of central and lateral lobes relatively numerous, diverging from primary veins at the right or almost right angle, join each other camptodromously forming loops, or else entering the teeth of lobe margin. Sometimes at the base of the involucre an outline of nut a scar visible. Nuts absent.

Comparison. Involucres from Ruszów belong to the form group of recent species *Carpinus betulus* L. The fossil involucres of this group are known from numerous Miocene and Pliocene localities in Europe (Berger 1953, Andreánszky 1959, Jung 1963, Roiron & Vernet 1978, Mai 1981, Knobloch 1986, Gregor 1982, 1986, Shvareva 1983, and others). Berger (1953) distinguished two forms of involucres: *Carpinus grandis* Ung. where involucres have serrate lobe margins, and *C. pyramidalis* Gaudin form with entire lobe margins. The second type of involucres is less frequent in the recent species; it occurs in *carpinizza* Neilr. form (Sokolov 1951). More strongly asymmetric involucres with distinctly serrate lobe margins occur in a related North American species *Carpinus caroliniana* Walt. (Jentys-Szaferowa 1958, Gregor 1986). Since the involucres from Ruszów have finely, sparsely serrate margins, they have been designated as *C. grandis* Ung. sensu Berger. They are very similar although slightly smaller, to the involucres of recent species *Carpinus betulus* L., and so are other involucres of the *C. betulus* L. form-group from various Miocene and Pliocene localities in Europe (Jentys-Szaferowa 1958, also observations of the author). *Carpinus caucasica* Grossh. is a recent species with slightly smaller involucres and more narrow lobes than in *C. betulus* L. The involucres of this species, similarly to the ones of *C. betulus* L., are often asymmetric, with irregular lobes, and sparsely serrate or entire margins. Basal secondary veins of the central lobe often run along a shorter or longer segment of the midvein, and then enter the teeth of the lobe margin or join into loops with a superadjacent pair of

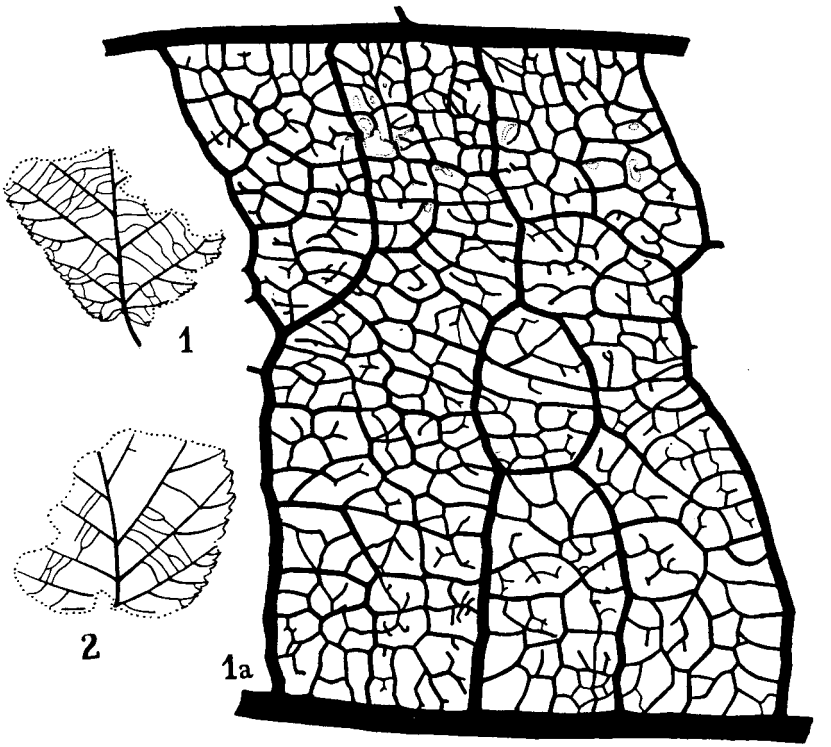

Fig. 13. *Corylus avellana* L. fossilis. 1 – specimen No MZ.VII/67/0/31, x 1; 1a – higher order venation, x 14, drawing by J. Wieser; 2 – specimen No MZ.VII/66/8/154, x 1

secondary veins. Higher up there are a number of pairs of secondaries which depart from midvein at an angle of approximately 90° and are craspedodromous or brochidodromous. Some of the involucres from Ruszów, due to their dimensions, are closer to *C. caucasica* Grossh. involucres than *C. betulus* L. However, in the examined *C. caucasica* comparative material no forms of equally asymmetric, wide-based and distinctly serrate central lobe have been found as are sometimes observed in fossil specimens (Fig. 12: 3, 7 and Berger 1953, Abb. 5: D–F). The investigation of nutlets found in the Ruszów flora could contribute significantly to the assignment of the fossil fruits from this flora (Baranowska-Zarzycka 1988).

Occurrence in Poland's fossil floras. Sośnica (Goeppert 1855, Reimann 1919).

Reference herbarial materials:

Carpinus betulus L. – Damvar. Croatia, coll. J. Schneider 1451 W; Prov. Skane, Sweden, coll. O. J. Hasslow 7732 W; Near Vienna, coll. Henschel, det. H. Winkler 7196 W; Near Linz, coll. Rauscher, det. H. Winkler 7199 W; Poland: Hajnówka, Prószków near Opole, leg. det. H. Czeczott WA ME

Carpinus caucasica Grossh. – Caucasus, leg. det. A. A. Kolakovsky Herb. of Bot. Gard. Sukhumi; Near Ritsa Lake, leg. A. Hummel WA ME; Sukhumi, leg. A. Hummel WA ME

Corylus avellana L. *fossilis*

Pl. 14, fig. 1–4a; Fig. 13

Material. Layer 8/2: Nos. MZ.VII/66/8/ 154, 284; layer 8/WL.O: No MZ. VII/67/0/31; two leaf fragments with preserved base; and one small, almost complete leaf.

Morphological description. Basal part of two leaves about 3.0 cm wide. Dimensions of preserved leaf fragments about 2.5 x 3.0 cm. Leaf base auriculate, asymmetric, with margin oblique on one side. Preserved fragment of leaf petiole 0.6 cm long. Leaf margins finely doubly serrate or dentate, at the base along short segment entire. Few preserved primary teeth shallow about 0.5 mm high and 1.5–2.0 mm wide at the base, with additional teeth or convexities occurring on one or both sides. Tooth sides convex, acuminate or straight. Secondary teeth in the preserved basal part 6–10 within two adjacent secondaries, 0.3–0.6 mm high and 0.7–1.5 mm wide at the base. Tooth apex usually acute, apical angle straight or acute; apical side concave, straight or convex; basal side acuminate, convex or straight and usually longer than the apical side, often provided with additional tooth or convexity. Sinuses between teeth angular.

Venation pinnate, simple craspedodromous. Midvein stout. The preserved 3–4 pairs of secondary veins branching from midvein at intervals of 4–9 mm at an angle of 40–70°, different on the two sides of midvein. Secondaries straight, alternate, the lowermost almost opposite. At the base 1–2 short veins, somewhat thinner than the secondaries, diverging from midvein at the right or obtuse angle, then recurved and terminating in leaf margin teeth. Outer branches, up to 5 per one lateral vein, distinct, running arcuately and terminating in second order teeth, the lowermost branch sometimes leaving lateral vein right at the midvein. Tertiary veins percurrent, opposite or alternate and then forked, usually perpendicular to secondaries, 6–8 per 1 cm of the secondary vein length. Higher order venation mostly orthogonal, distinctly marked (Fig. 13: 1a). Areoles well developed or imperfect, arrangement random or oriented. Veinlets usually branched once, simple or none. Marginal ultimate venation looped.

The almost complete specimen is a small, wide elliptic leaf of dimensions about 2.0 x 1.5 cm (preserved part being 1.8 x 1.5 cm), with apex missing, base asymmetric, auriculate (Pl. 14, fig. 3, 3a). Leaf margin doubly serrate, slightly emarginate; seven pairs of secondary veins leaving distinctly marked outer branches.

Anatomical description. Cuticle poorly preserved. Cells of upper epidermis isodiametric or slightly elongated, 20–25 (30) μm in the longest diagonal (Pl. 14, fig. 1). Anticlinal walls of cells slightly, uniformly cutinized, mostly undulate, sometimes straight or rounded. Cells of lower epidermis invisible. Stomatal apparatus of unknown type. Stomata 16–20 x 16 μm with epidermal walls of guard cells poorly visible (Pl. 14, fig. 2). Distinctly marked only outer stomatal ledges of 13–20 x 6–11 μm surrounding spindle-shaped outer stomatal ledge aperture. Pore about 8 x 1 μm sometimes visible. Hair bases not found.

Comparison. Preserved leaf fragments have been assigned to *Corylus* due to the shape of their leaf base, leaf margin development, course of secondary veins and number of distinct outer branches in the basal part of the lamina. All the cuticular features seen on the anatomical microscopic slides occur in cuticles of recent *Corylus* leaves.

The presence of this genus in the Ruszów flora was confirmed by the examinations of the carpological remains (Stachurska et al. 1967, Baranowska-Zarzycka 1988). From the Tertiary floras of Europe, two fossil *Corylus* leaf taxa have been usually distinguished *C. Mac Quarrii* (Forbes) Heer and *C. insignis* Heer. The former, initially reported from the Miocene Artun Head in Scotland and described as *Alnites? Mac Quarrii* (Forbes 1851), was then assigned to genus *Corylus* by Heer (1856). Its characteristics includes wide elliptic leaves with auriculate base, acuminate apex and triple serrate margins. However, not all the leaves of *Corylus Mac Quarrii* (Forbes) Heer assigned in fossil floras from a number of localities in North America (Newberry 1898, Hollick 1936), Arctic Zone (Heer 1868, 1869a, 1878) and Europe (Heer 1856, Ettingshausen 1872, Laurent 1912, Walther 1964) are *Corylus* leaves. The leaf remains of this fossil taxon need critical investigation.

Another fossil species *Corylus insignis* Heer was described by Heer (1856) from the Miocene of Switzerland. It has elliptic-ovate leaves with a rounded base and acuminate apex, and has been compared with the recent species of North American hazel *C. rostrata* Ait. (= *C. cornuta* Marsh.). The leaves of *C. insignis* Heer are known from a number of localities of the European Oligocene, Lower and Middle Miocene: Switzerland (Heer 1856), Bilina (Ettingshausen 1867), Kundratice (Engelhardt 1885), Czermniky (Bůžek 1971); also from the Upper Miocene floras of Zschipkau (Menzel 1906), Lower Lusatia (Menzel et al. 1933), Ambrosievka (Pimenova 1954), Krynka (Krishtofovich & Baykovskaya 1965) and Kortumova Gora (Shvareva 1983); and from the Pliocene of Duab (Kolakovsky 1958).

Due to their considerable width, the shape of the base and intervals between secondary veins, the fragments of Ruszów leaves resemble *Corylus Mac Quarrii* (Forbes) Heer, but their closest match is with the recent *Corylus avellana* L. They are very similar to the leaves designated as *C. avellana* L., reported from the Miocene flora of Joursac (Marty 1903) and from the Pliocene of Duab (Kolakovsky 1956), and also to the leaves Corylus cf. avellana L. from Kortumova Gora (Shvareva 1983), Ambrosievka (Pimenova 1954) and the Sarmatian of Hungary (Andreánszky 1959).

Today *Corylus avellana* L. occurs in Europe (except for Scandinavia and the Pyreneean Peninsula) and the South-West Asia. It grows as brushwood component in broad-leaved or mixed deciduous forests and in mountain coniferous forests. In the mountains, it reaches the upper limit of the forest, in the Caucasus it occurs as high as 2,100–2,300 m above sea level. It is also found on lake and river banks, and on hill slopes (Sokolov 1951).

Occurrence in Poland's fossil floras. *Corylus* leaves are not known from the Tertiary floras of Poland. Nuts are reported from Gdów Bay (Łańcucka-Środoniowa 1966), Stare Gliwice (Szafer 1961) and - primarily - from the Pliocene floras of Krościenko (Szafer 1947), Mizerna (Szafer 1954) and Ruszów (Stachurska et al. 1967, Baranowska-Zarzycka 1988).

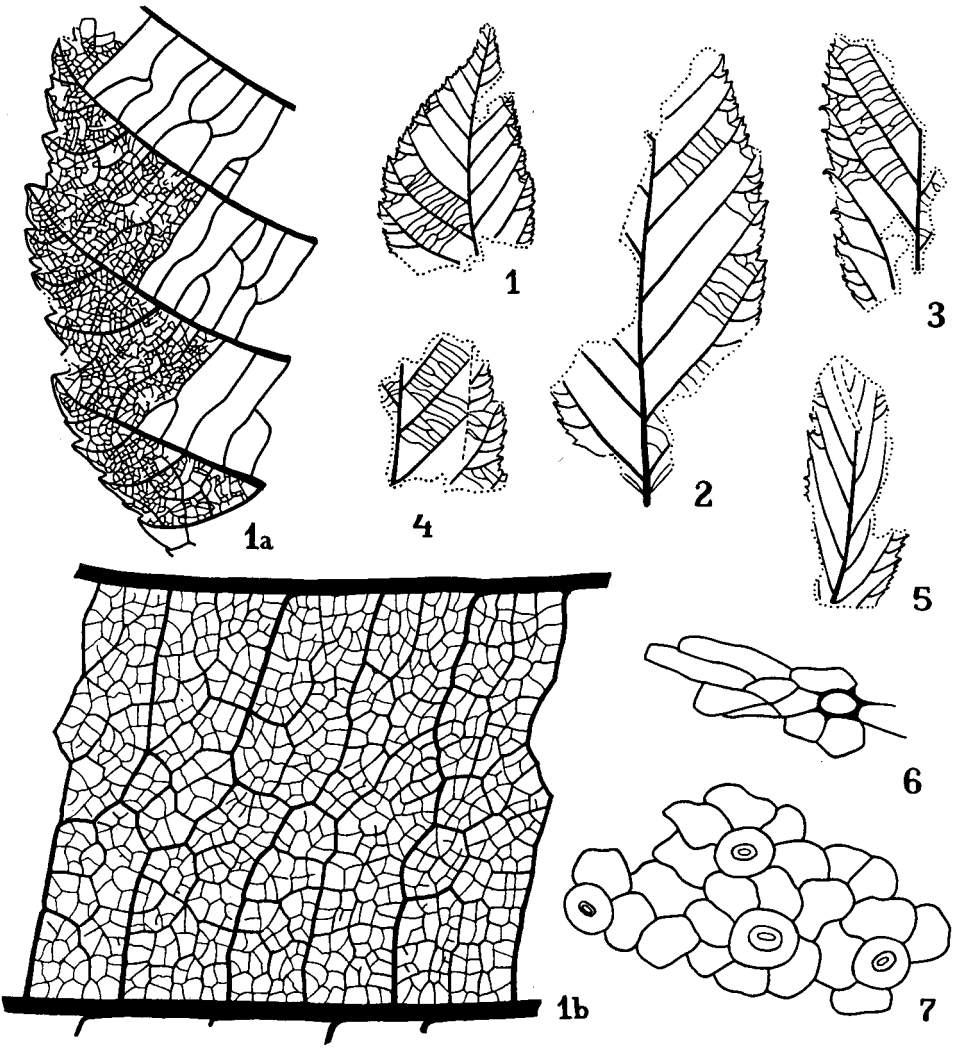

Fig. 14. *Ostrya carpinifolia* Scop. fossilis. 1 – specimen No MZ.VII/67/I/65, x 1; 1 a – enlargement of the leaf margin, x 4; 1 b – higher order venation, x 14, drawing by J. Wieser; 2 – specimen No MZ.VII/67/II/4, x 1; 3 – specimen No MZ.VII/67/0/1, x 1; 4 – specimen No MZ.VII/67/I/38, x 1; 5 – specimen No MZ.VII/67/0/33, x 1; 6 – lower epidermis, circular trichome base, specimen No MZ.VII/67/I/38, x 500; 7 – lower epidermis, stomata, specimen No MZ.VII/67/I/65, x 500

Ostrya carpinifolia Scop. *fossilis*

Pl. 15, fig. 1–5, Pl. 16, fig. 1–3; Fig. 14

Material. Layer 8/WL.O: Nos. MZ.VII/67/ 1, 33; layer 8/WL.I: Nos. MZ.VII/67/I/ 38, 65; layer 8/WL.II: No MZ.VII/67/II/ 4; five fragments of leaves, including one with preserved apex and one with preserved base.

Morphological description. Leaves narrow oblong or elliptic-ovate, some-

times asymmetric, 4.0–7.5 cm long and 1.5–3.5 cm wide at the base. The preserved leaf apex acuminate, the preserved base cuneate. Petiole missing. Leaf margins at the base entire, higher up doubly serrate, usually slightly emarginate (Fig. 14: 1a). Primary teeth, entered by secondary veins, 0.5–1.5 mm high and 0.75–2.5 mm wide at the base, apex of teeth acute, apical angle acute, apical and basal sides for the most part acuminate, almost of the same length, sometimes with a small additional tooth. Secondary teeth 1–3 (5) between two adjacent secondaries (more numerous in basal part of the leaf), with acute apex and apical side, of dimensions within limits 0.3–1.0 mm in length and 1.0–2.0 mm width at the base; apical side short, usually straight; basal side longer than apical, convex, acuminate or less frequently concave, often provided with a small additional tooth. Sinuses between teeth angular.

Venation pinnate, simple craspedodromous. Midvein moderate, straight or curved. Secondary veins (about 10 pairs) arising from the primaries at the intervals of 2–7 (9) mm, at angles of 30–40 (55)°, usually increasing toward the base, and sometimes different on the two sides of primary vein. Secondaries running straight or slightly curved, arranged alternately, and the lowermost – subopositely. Outer branches, up to 4 (5) per one secondary vein, strongly impressed, entering teeth of second order. A pair of thin veins running right at the base parallelly to the leaf margin. Intersecondary veins found sporadically, only within leaf apex. Tertiary veins percurrent, usually distinctly marked, originating at nearly right angles on either side of secondaries, 10–12 (14) per 1 cm of the secondary vein length, arranged regularly oppositely or alternately and then forked approximately half-way between two adjacent secondaries. Higher order venation of orthogonal course, areolation well developed with oriented arrangement of areoles, veinlets simple or none (Figs 14: 1b). Marginal ultimate venation looped.

Anatomical description. Upper epidermis composed of polygonal, isodiametric or slightly elongated cells which longest diagonal fluctuating within limits of 13–24 (28) μm (Pl. 16, fig. 1). Anticlinal walls of cells slightly uniformly thickened, straight, rounded or slightly undulate, length of walls measured along a straight line being 6–22 μm (most frequently 10–16 μm). Only on one fragment of cuticle a three-celled base of presumably glandular hair is visible, its dimensions being 15 x 13 μm. Cells of lower epidermis poorly visible. The longest diagonal within limits 10–16 (20) μm. Anticlinal walls of cells straight, rounded or slightly undulate, 5–13 (15) μm in length measured along straight line.

Stomatal apparatus anomocytic (Fig. 14: 7). Stomata relatively dense, irregularly distributed in non-venous areas, usually small and circular, their dimensions being 11–15 (20) x 11–15 (16) μm. Slightly thickened outer stomatal ledges (Pl. 16, fig. 3), 5–7 (10) μm in length and 4–6 μm in width, surrounding outer stomatal ledges aperture, often circular in shape. Pore narrow, short, 3–5 μm in length. Epidermal walls of guard cells thin. Small, circular trichome bases about 10 μm in diameter sporadically visible (Pl. 16, fig. 2; Fig. 14: 6). Poral and partially radial walls of trichome-base cells thickened.

Comparison. The leaves of recent *Ostrya* and *Carpinus* species are difficult to differentiate based on morphological features – in fossil specimens, where we have small and usually damaged leaf fragments, it is sometimes practically impossible. In case of

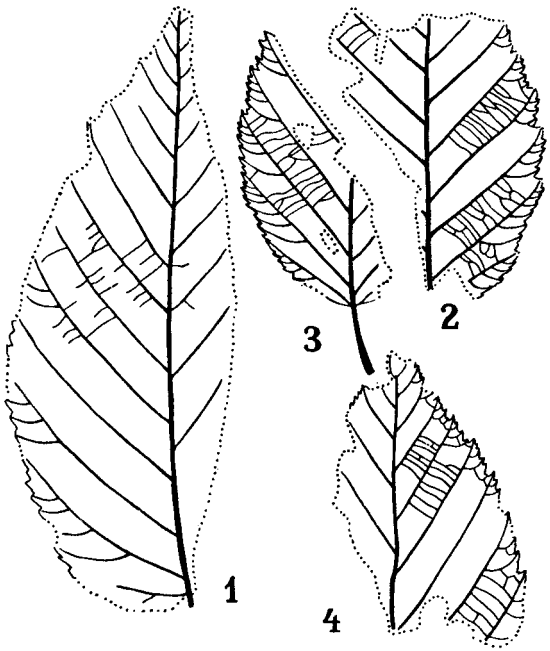

Fig. 15. *Ostrya* vel *Carpinus*, natural size. 1 – specimen No MZ.VII/66/8/23; 2 – specimen No MZ.VII/67/I/75; 3 – specimen No MZ.VII/67/0/10; 4 – specimen No MZ.VII/67/0/65

leaf remains from Ruszów it was possible to assign the *Ostrya* leaves due to preserved fragments of cuticle which is different from the cuticle of *Carpinus* leaves. The cells of the upper and lower epidermis of *Ostrya* leaves are usually smaller than those of the fossil hornbeam from Ruszów; anticlinal cell walls are usually straight or rounded, sometimes slightly undulate, whereas in *Carpinus grandis* Ung. emend. Heer leaves the cell walls generally strongly undulate. Stomata in *Ostrya* leaves are smaller, circular or oblong, pore is shorter, and there are no distinctly marked rounded or wing-shaped thickening of stomatal ledges, whereas such ledges occur in the epidermis of Ruszów hornbeam.

The anatomical structure of *Ostrya* leaves from Ruszów corresponds to that of recent *Ostrya carpinifolia* Scop. (Pl. 16, fig. 4). The size and shape of epidermal cells are similar, and so is the structure of stomata which in recent species are circular, relatively small and have wide oblong outer stomatal ledge aperture. *Ostrya carpinifolia* Scop. have small circular bases of unicellular hairs and uni- or multi-cellular bases of spherical glandular hairs which correspond to trichome bases observed in the epidermis of the fossil leaves.

In terms of morphological features, the *Ostrya* leaves from Ruszów stay within the variability limits of recent *O. carpinifolia* Scop. which often has asymmetric leaves and slightly curved midvein (Pl. 15, figs 4, 4a), serrato-emarginate leaf margins, teeth with acute apex, sometimes pointing laterally (Pl. 15, fig. 2, 2a), as well as distinctly marked,

numerous outer branches of secondary veins and distinct tertiary venation pattern (Pl. 15, figs 3, 3a, 4, 4a).

Today *Ostrya carpinifolia* Scop. occurs in South-East Europe, in the Caucasus and in Asia Minor. It grows in ravines and on mountain slopes in broad - leaved forests with oak-trees, ash-trees, hornbeams, beeches and elms, rarely in homogeneous forests (Sokolov 1951).

Occurrence in Poland's fossil floras. *Ostrya* leaves have not been reported yet. Nuts from *Ostrya carpinifolia* Scop. fossilis are reported from the Pliocene of Krościenko (Szafer 1947) and Ruszów (Jentys-Szaferowa 1975, Stachurska et al. 1967).

Reference herbarial materials:

Ostrya carpinifolia Scop. – Trans-Caucasian Region, leg. det. W. Massalsky LE; Caucasus, leg. det. Marcowitsch LE; Istria, region Monte Maggiore, coll. A. Grinzberger 3089 WU; Dalmatia, Cattaro, coll. F. Vierhapper 2062 WU; Georgia, leg. det. A. A. Kolakovsky Herb. of Bot. Gard. Sukhumi

Ostrya japonica Sarg. – Flora of Hokkaido, vicinity of Sapporo, leg. det. T. Tanaka 191 LE

Ostrya knowltonii Coville – California, leg. det. C. S. Sargent LE;

Ostrya liana Hu. – Hopei, leg. Lin Y 13862 LE

Ostrya virginica Willd. – Vera Cruz, near Jalapa, coll. C. G. Pringle 1969 WU; N. Carolina, near Baltimore 1817 WU

Ostrya vel *Carpinus*

Fig. 15

Material. Layer 8/1: No MZ.VII/66/8/ 23; layer 8/WL.O: Nos. MZ.VII/67/0/ 10, 65; layer 8/WL. I: No MZ.VII/67/I/ 75; four leaf fragments including two with partly preserved apex and two with partly preserved base.

Morphological description. Leaves elliptic to elliptic-ovate of dimensions 5.0–8.5 x 3.0–4.5 cm. Leaf apex apparently acuminate or acute, base rounded to (most probably) cordate. Length of preserved petiole fragment 1.0 cm. Leaf margins doubly serrate, usually slightly emarginate, at the base entire. Teeth of first order frequently with an additional tooth on one or either sides. Teeth of second order, 1 to 5 between two adjacent secondary veins, sometimes with an additional tooth or convexity on the longer side.

Venation pinnate, simple craspedodromous. Primary vein straight, moderately thick. Secondary veins in 10–12 pairs, usually straight, sometimes slightly curved, running alternately or subopposite, parallelly to each other, at the distances of (2) 4–7 (10) mm, angle of departure from midvein being 35–45 (55)°. Outer branches up to 5 per 1 secondary vein, in most cases distinctly marked (Fig. 15: 3, 3 a). Intersecondary veins not observed. Tertiary veins percurrent, simple or forked, running 10 to 12 per 1 cm of a secondary vein length, usually regular, perpendicular to secondaries. Higher order venation orthogonal; areoles well developed, arrangement oriented. Veinlets none or simple. Marginal ultimate venation looped.

Anatomical description. Cuticle poorly preserved. Cells of upper and lower epidermis poorly visible, isodiametric or slightly elongated; anticlinal walls of cells

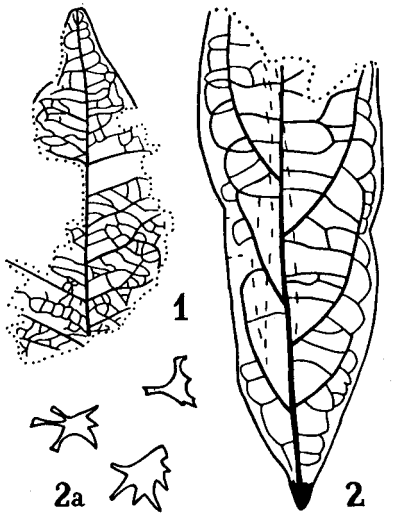

Fig. 16. 1 – *Phyllites* sp. 3, specimen No MZ.VII/67/0/7, x 1; 2 – *Phyllites* sp. 4, specimen No MZ.VII/67/I/81, x 1; 2a – sclereids, x 500

straight, rounded or slightly undulate. Longest diagonal of cells of the upper epidermis fluctuating within limits 16–24 (28) μm and of the lower epidermis – within limits 11–20 (24) μm. Length of cell walls in the upper epidermis being 5–16 (24) μm, in the lower epidermis 5–16 μm. Stomatal apparatus anomocytic. Shape and size of stomata varying, depending on the specimen. On the cuticle of one leaf circular or oblong stomata observed, its dimensions being 16–21 x 15–20 μm; slightly thickened outer stomatal ledges surrounding oblong outer stomatal ledge aperture; pore 5–8 (10) μm long. In the second specimen with stomata of similar size wing-shaped thickening of stomatal ledges clearly marked on both sides of narrow and short pore (3–5 μm long). In the third specimen, stomata small, circular or oblong, (11) 13–16 μm in length and 11–16 μm in width, having pore of 3–6 (8) μm and slightly marked wing-shaped stomatal ledges. Hair bases not found.

Comparison. Morphological features of these remains have more resemblance to *Ostrya* (numerous, distinct outer branches, relatively well marked tertiary venation). However, due to the presence of the epidermal features characteristic of *Ostrya carpinifolia* Scop. foss. from Ruszów (stomata small, circular, pore narrow, short), beside features typical of *Carpinus grandis* Ung. emend. Heer (stomata bigger, with wing-shaped thickening of stomatal ledges), it is not possible to decide about the assignment of the these specimens.

Betulaceae vel *Rosaceae* gen. et sp. div.

Material. Layer 3: No MZ.VII/66/3/ 21; layer 8/2: Nos. MZ.VII/66/8/ 108, 204, 212, 261, 287; layer 8/WL.I: No MZ.VII/67/I/ 24; seven leaf fragments including four with

preserved base.

Small leaf fragments of various type of margin serration. Some of them resemble the leaves of *Rosaceae*. Due to poor preservation of the remains, the fragments have not been precisely assigned.

Phyllites sp. 3

Pl. 17, fig. 1, 1a, 1b; Fig. 16: 1

Material. Layer 8/WL.O: No MZ.VII/67/0/ 7; a single leaf fragment with preserved apex.

Morphological description. Poorly preserved leaf fragment about 5.0 cm long and 2.5 cm wide. Apex of leaf acute, on the top rounded, base missing, margin entire. Venation apparently brochidodromous. Midvein straight, in apical part of leaf slightly curved, moderately thick. Secondary veins relatively thin, subopposite or alternate, diverging from midvein at an angle of 60–70°, running basically straight (slightly sinuous with respect to the branching points of tertiaries); branching out at various distances from midvein; the branches of adjacent veins joining each other in arches. One or more series of loops of higher order veins occurring near leaf margin outside loops of second order veins. Intersecondary veins, one to two between adjacent secondaries, sometimes running as far as about two-thirds of the distance between midvein and leaf margin. Tertiary veins in intercostal areas predominantly randomly reticulate. Higher order venation poorly visible, in intercostal areas most probably randomly oriented. Veinlets invisible. Marginal ultimate venation looped.

Anatomical description. Upper epidermis. Cuticle poorly preserved. Only few small fragments of cuticle show indistinct outlines of square to hexagonal cells 13–21 (21) μm in the longest diagonal, anticlinal walls of cells straight, slightly uniformly cutinized, 3–16 μm in length. These features suggest that the fragments could belong to the upper surface of the leaf. Lower epidermis. Cells nearly isodiametric with longest diagonal (16) 19–24 (30) μm. Anticlinal walls of cells undulate, irregularly cutinized, length of walls measured along straight line 5–16 (22) μm. Stomatal apparatus anomocytic. Stomata circular, sometimes oblong or with the width exceeding their length, 24–29 μm in length and 19–23 μm in width (Pl. 17, fig. 1b). Outer stomatal ledges surrounding spindle shaped apertures of 8–11 x 2–3 μm. Between poorly marked outer stomatal ledges and slightly cutinized epidermal walls of guard cells there are distinct thickenings of cuticle forming a ring about 5 μm thick. Stomata irregularly but usually densly distributed in non-venous areas. Stomatal Index about 10–14 per cent. Other epidermal formations invisible.

Comparison. The poorly preserved remain precludes more detailed examination. Similar morphological features occur in a number of recent leaf species. The specimen's venation closely resembles venation of remains reported from Ruszów as *Myrica lignitum* (Ung.) Sap. sensu stricto (Hummel 1983). However, leaves of this specimen are considerably narrower. Sometimes wider and entire margin leaves can be found among recent *Myrica* species, but their apex is usually more rounded than that of the examined remain. Leaves with similar apex and venation pattern, but with a more regular second-

ary venation course, have been found in *Engelhardtia spicata* Bl. In the reference cuticle material of *Myrica* and *Engelhardtia* species, stomata with distinct thickenings of cuticle forming a ring, similar to those of the examined remain, have not been found. Assignment is also difficult due to the lack of trichome bases in the cuticle.

The stomata of the cuticle designated by Litke (1966, Pl. 34, fig. 1, 2, Abb. 21e) as NFu 27 have similar structure to those of the Ruszów cuticle, but they are considerably bigger (approx. 35–45 μm).

Phyllites sp. 4

Pl. 17, fig. 2a, 20, Pl. 18, fig. 1–5; Fig. 16: 2, 2a

Material. Layer 8/WL. I: No MZ.VII/67/I. 81; one fragment of basal part of leaf.

Morphological description. Basal part of entire- margined, probably narrow elliptic leaf, about 3.0 cm in width (preserved fragment 6.8 cm long and 2.3 cm wide); leaf base acute with a thickening at the petiole. Petiole missing. Venation pinnate, camptodromous. Primary vein straight, moderately thick. Three to four relatively thin secondaries diverging alternately on both sides of midvein, at the angle of about 60°, at intervals 8–20 mm decreasing to the leaf base; secondaries uniformly curving toward leaf apex, then ascending along the margin and connecting with tertiary veins which originate exmedially from superadjacent secondary veins, to from a series of prominent arches. Intersecondary veins absent. Intercostal tertiary veins percurrent, simple or forked, originating from secondaries and midvein usually at nearly right, less often acute angle, about 3 to 5 per 1 cm of the length of secondary vein; distal exmedial tertiaries joining in the loops. Higher order venation poorly marked. Areoles imperfect and/or most probably incomplete. Veinlets branched several times. Marginal ultimate venation looped.

Anatomical description. On the only one obtained slide with anatomical preparation the upper and lower cuticles overlap. They can be seen separately in very small fragments. Cells of upper epidermis isodiametric or slightly elongated; their longest diagonal fluctuating within limits (24) 33 (50) μm. Anticlinal walls of cells strongly undulate, their wave length of 8–12 μm, amplitude 5–8 μm; walls irregularly thickened with numerous knotty thickenings. Cells over the veins rectangular, several times elongated with straight longer walls, and with shorter walls straight or rounded. The lower epidermis composed of isodiametric or slightly elongated cells of (24) 33 (45) μm in the longest diagonal. Anticlinal walls of cells strongly undulate, similarly to the ones of the upper epidermis. However, the walls more regularly thickened with fewer knotty thickenings.

Stomatal apparatus paracytic or brachyparacytic, sometimes hemiparacytic (Pl. 18, fig. 1, 2). Anticlinal walls of subsidiary cells mostly straight or rounded, sometimes one of subsidiary cells with undulate walls. Stomata circular, their dimensions fluctuating within limits (21) 24 (28) x (16) 21–24 (28) μm, measured together with bilaterally arranged subsidiary cells of 24–32 x 32–45 μm. Outer stomatal ledge aperture oblong, sometimes circular, surrounded by thickened outer stomatal ledges. Dimensions of aperture, including outer stomatal ledges, 10–15 x 6–15 μm. Stomata irregularly distributed

in non-venous areas. Stomatal Index 8–11 per cent. Over the veins and in non-venous areas of the upper and lower epidermis uniseriate hairs (Pl. 18, fig. 3) occurring in the amount of 1–6 on 200 x 200 µm. Trichome bases circular, strongly cutinized, 11–16 µm diameter (Pl. 18, fig. 4); trichome-base cells with straight, strongly irregularly thickened radial walls. Sometimes only the lowermost cell of hair about 33 µm long and 13 (20) µm wide at the base preserved; some other times longer hair fragments up to 100 µm found. Infrequently observed fragments of bigger hairs about 130 µm in length, and about 30 µm in width at the base. Among epidermal cells sclereids (Pl. 18, fig. 5; Fig. 16: 2a) sporadically visible: stellate, thick-walled, 16–28 x 8–16 µm in size, with branches of acute or truncate apex.

Comparison. Paracytic type of stomatal apparatus occurs in leaves of similar shape, margin development and venation pattern which belong to a number of recent species from various families. Stellate sclereids, found in the cuticle of Ruszów leaf, suggest that this remain could be assigned to the *Theaceae* family (Kvaček, oral communication). This suggestion is also confirmed by the analysis of the remain's morphological features. However the leaf epidermis of different species from this family usually has two other types of stomatal apparatus. Paracytic type occurs only in few species (Solereder 1899, Keng 1962, Kvaček & Walther 1984). Among the species with paracytic type of stomatal apparatus, the cuticle of *Hartia sinensis* Dunn. was examined. In the examined cuticular fragments sclereids have not been found. Detailed assignment of the remain would require further comparative studies of more herbarial materials.

RESULTS

The family *Betulaceae* from the flora of Ruszów, next to *Fagaceae* as far as the number of specimens is concerned, is represented by ten fossil taxa from the genera: *Alnus, Betula, Carpinus, Corylus* and *Ostrya*. Most numerous are the leaves of *Carpinus grandis* Ung. emend. Heer (70) and the accompanying involucres of *C. grandis* Unger sensu Berger (13). This confirms a considerable representation of hornbeam in the vegetation of the Ruszów area; such representation was indicated earlier, based on the analysis of fruit and seed remains from that locality (Jentys-Szaferowa 1975, Baranowska-Zarzycka 1988).

Genus *Alnus* is represented by three leaf taxa. It is interesting to note the presence of leaves *Alnus julianaeformis* (Sternb.) Kvaček et Holý, the species typical primarily of Central-European Miocene (Knobloch & Kvaček 1976). Birch leaves belong to three taxa, one of them – *Betula plioplatyptera* Hummel nov. sp. – being new for the Tertiary. The cuticles of *Betula subpubescens* Goepp. and of *Corylus avellana* L. foss. and of *Ostrya carpinifolia* Scop. foss. are described for the first time. The leaves of the two latter species have not been reported from Poland's Tertiary before. The specimen group of *Dicotyledoneae* incertae sedis (Hummel 1983 p. 82) has been supplemented with two leaf fragments of *Phyllites* sp. 3 and *Phyllites* sp. 4, which are provided with a detailed morphological and anatomical characteristics. One of the fragments, due to the presence

of characteristic sclereids in the cuticle, could belong to family *Theaceae*.

Taxa of *Betulaceae* in the Ruszów flora belong mostly to species characteristic of Middle and Upper Miocene. Some of them, like *Betula subpubescens* Goepp. and *Carpinus grandis* Ung. emend. Heer, have already been found in Middle Oligocene; their development peaked in Miocene, and they probably survived to Upper Pliocene. Two species, *Corylus avellana* L. fossilis and *Ostrya carpinifolia* Scop. fossilis, link the flora of Ruszów with recent floras. Their presence confirms the Pliocene age of the Ruszów flora (Hummel 1983).

ACKNOWLEDGEMENTS

I would like to extend my thanks to all those who have helped me to complete this paper, and especially to the authorities of the Museum of the Earth, Polish Academy of Sciences, in Warsaw, for their cooperative attitude and support; to Dr. Ewa Zastawniak, Assistant Professor at the W. Szafer Institute of Botany, Polish Academy of Sciences, in Cracow, for her consultations and numerous valuable suggestions concerning my work; to RNDr. Zlatko Kvaček DrSC, Assistant Professor at the Institute of Geology and Geotechnics, Czechoslovak Academy of Science, in Prague, for the discussions and remarks concerning anatomical examination of cuticles. I would like to thank all those who provided me with access to reference materials from herbaria in Poland and in other countries. I owe special thanks to Dr. Johanna Kovar-Eder from the Naturhistorisches Museum in Vienna, and to Dr. Franz Stojaspal from Geologische Bundesanstalt in Vienna for offering me access to the original materials. I would also like to thank Mrs. Maria Kleiber for taking photographs of the fossil specimens, Mr. Leszek Dwornik for helping me in photographing the anatomical slides, and Mrs. Katarzyna Krajewska for her help in the designing of drawings.

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STRESZCZENIE

W kontynuacji badań nad florą liściową z Ruszowa koło Żar (por. Hummel 1983) opracowano szczątki kopalne z rodziny *Betulaceae* oraz *Dicotyledones* incertae sedis. Na podstawie badań morfologiczno-porównawczych i anatomicznych wyróżniono następujące taksony liści kopalnych: *Alnus julianaeformis* (Sternberg) Kvaček et Holý, *Alnus menzelii* Ran.-Bobr., *Alnus* sp., *Betula plioplatyptera* sp. nov., *Betula subpubescens* Goepp., *Betula* sp., *Carpinus grandis* Unger emend. Heer, *Carpinus grandis* Unger sensu Berger (okrywy owocowe), *Corylus avellana* L. *fossilis*, *Ostrya carpinifolia* Scop. *fossilis*, *Ostrya* vel. *Carpinus*, *Betulaceae* vel *Rosaceae* oraz *Phyllites* sp. 3 i 4. Opisany nowy gatunek brzozy *Betula plioplatyptera* Hummel odznacza się charakterystycznym przebiegiem nerwów w obrębie podstawy, kształtem ząbków brzegów liści oraz budową aparatów szparkowych. Po raz pierwszy zbadano i opisano nabłonek *Betula subpubescens* Goepp. oraz *Ostrya carpinifolia* Scop. *fossilis* i *Corylus avellana* L. fossilis. Rezultaty badań przedstawionych w niniejszym opracowaniu potwierdzają sugestię dotyczącą wieku flory z Ruszowa podaną na podstawie badań zawartych w pierwszej części opracowania (Hummel 1983), potwierdzają również przedstawione uprzednio wnioski dotyczące ogólnego charakteru reprezentowanych w niej zbiorowisk roślinnych.

PLATES

Plate 1

Alnus julianaeformis (Sternberg) Kvaček et Holý

1. Specimen No MZ.VII/67/I/63, x 1
2. Specimen No MZ.VII/66/8/166, x 1
3. Specimen No MZ.VII/67/I/11, x 1

3a. Enlargement of the leaf fragment, x 4

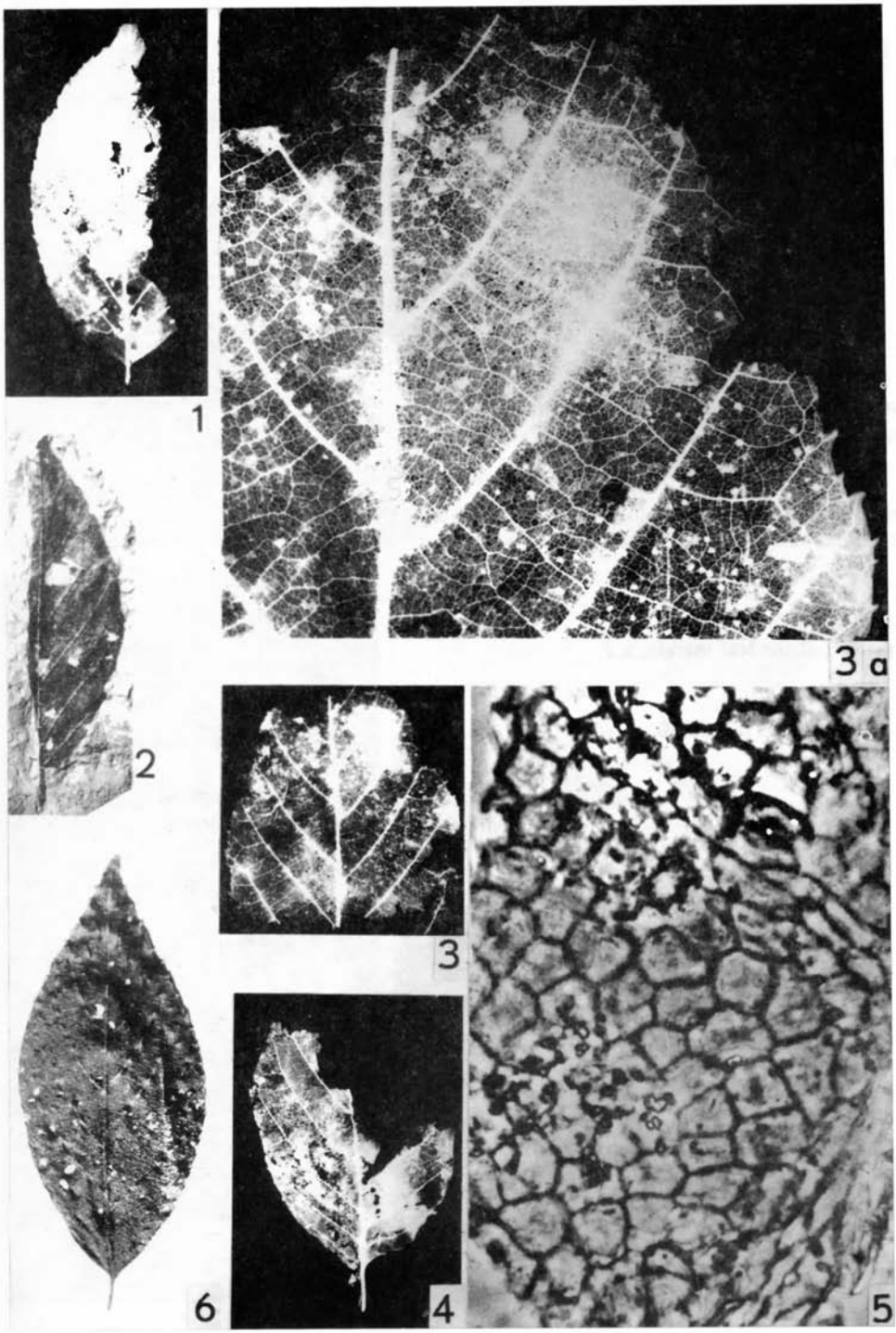
4. Specimen No MZ.VII/67/0/39, x 1
5. Upper epidermis, specimen No MZ.VII/67/I/63, x 600

Alnus japonica Sieb. et Zucc.

6. Nippon, leg. Maximovich, det. Cherepanov, LE, x 1

1–4 – phot.. M. Kleiber
5 – phot.. A. Hummel

Plate 1



A. Hummel

Acta Palaeobot. 31 (1,2)

Plate 2

Alnus trabeculosa Hand.-Maz.

1. Lower epidermis: stomata and glandular hair, x 600;
Kvangtung, coll. W. T. Tsang, det. E. D. Merrill 4621 W

Alnus julianaeformis (Sternberg) Kvaček et Holý

2. Lower epidermis: stomata and four-celled trichome base (X);
specimen No MZ.VII/67/0/39, x 600

Alnus sp.

3. Specimen No MZ.VII/66/8/49

3a. Enlargement of the leaf margin, x 2

Alnus menzelii Ran.-Bobr.

4. Specimen No MZ.VII/66/8/30

1, 2 – phot. A. Hummel
3, 4 – phot. M. Kleiber

Plate 2

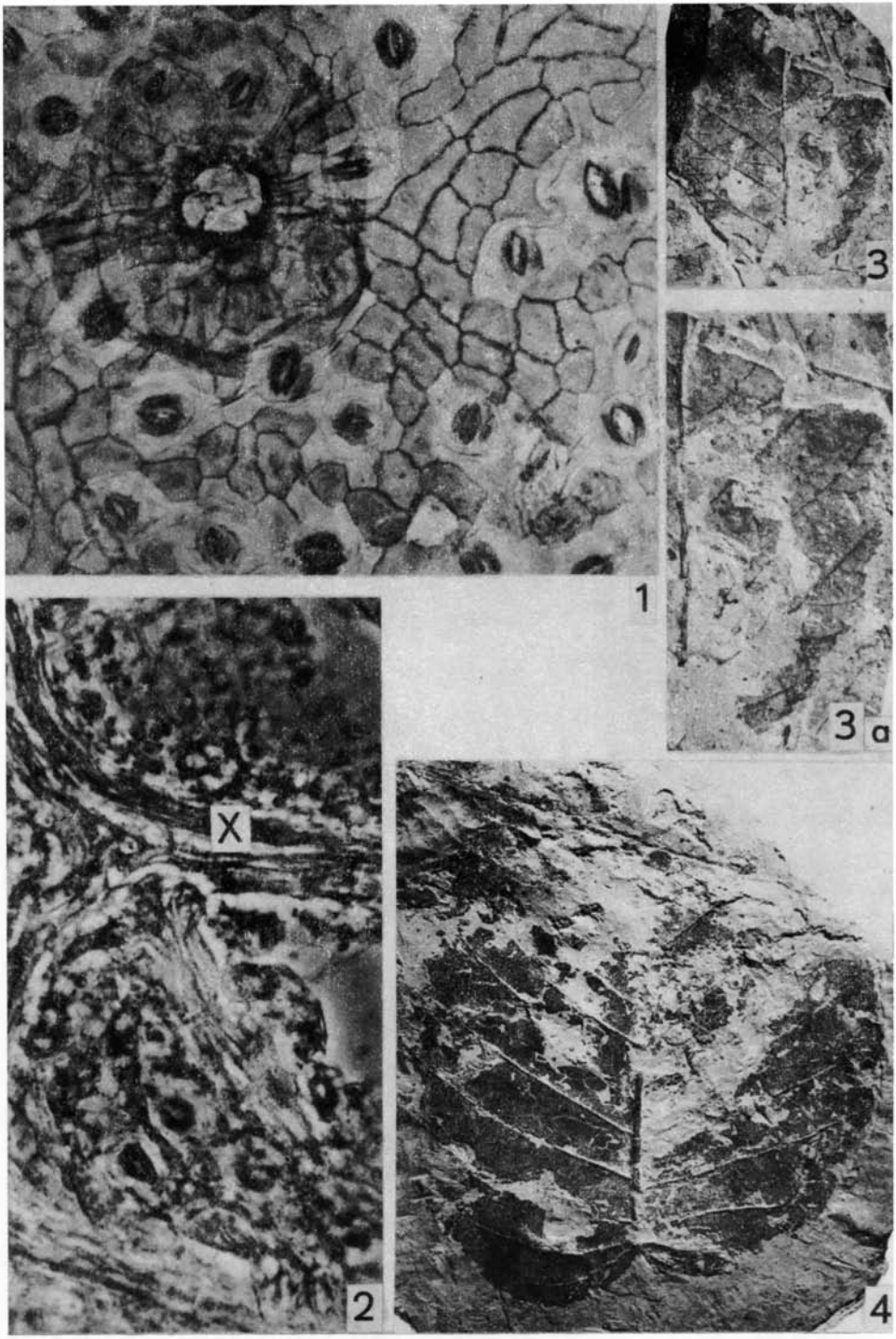


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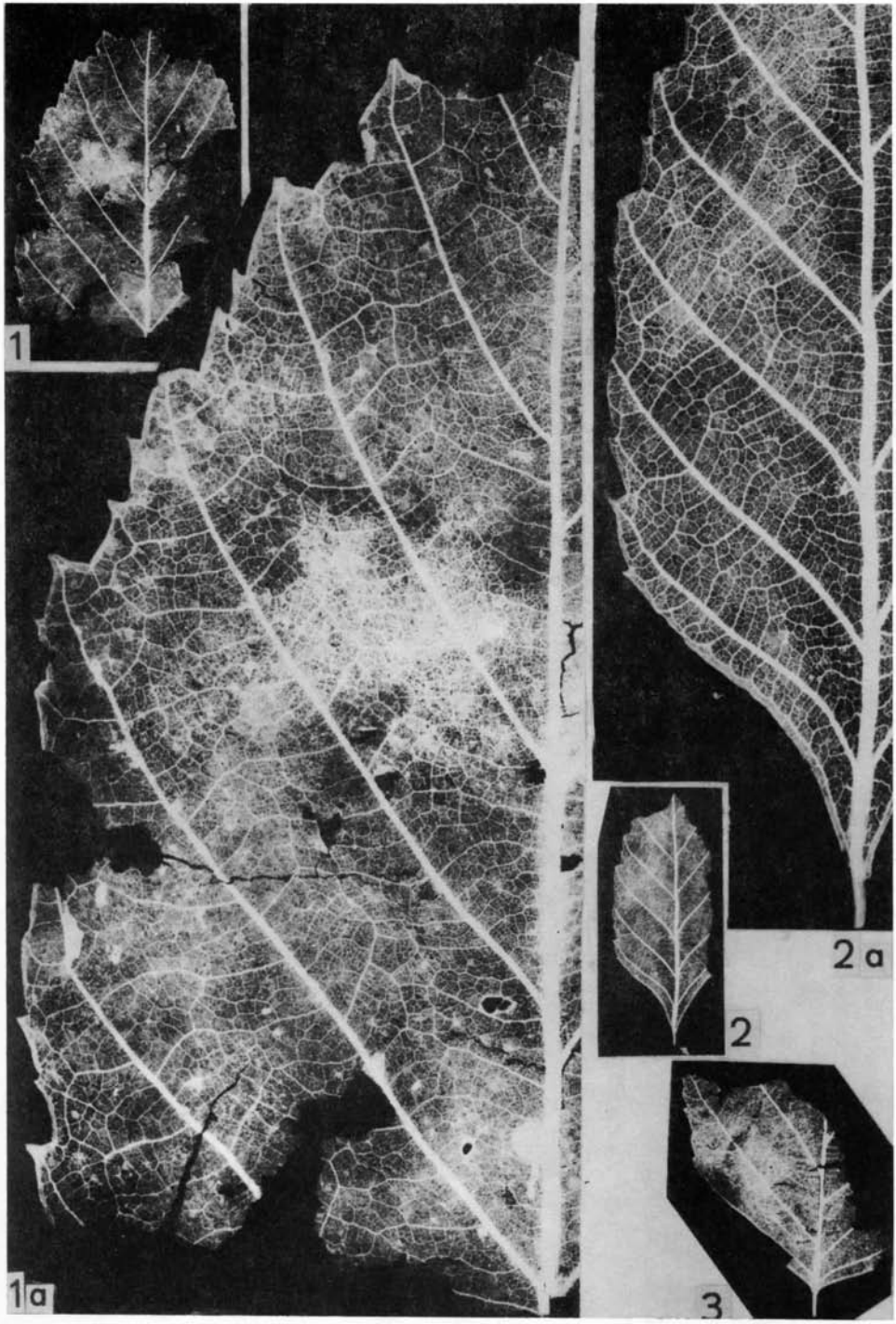
Plate 3

Betula plioplatyptera sp. nov.

1. Holotype, specimen No MZ.VII/67/0/26, x 1
1a. Enlargement of the leaf fragment, x 4
2. Specimen No MZ.VII/67/0/56, x 1
2a. Enlargement of the leaf fragment, x 4
3. Specimen No MZ.VII/67/0/20, x 1

phot. M. Kleiber

Plate 3



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Acta Palaeobot. 31 (1,2)

Plate 4

Betula plioplatyptera sp. nov.

1. Paratype, specimen No MZ.VII/67/0/24, x 1
1a. Enlargement of the leaf, x 4

Betula papyrifera Marsh.

2, 3. South Bay, Mounth (Canada), coll. det. D. R. Lindsay 3137 WU

Betula platyptera Ettingshausen

4. Twin impression of syntype (Ettingshausen 1872, Pl. 3, fig. 25)

1 – phot. M. Kleiber
2, 3 – phot. M. Dąbrowska
4 – phot. G. Pascher

Plate 4

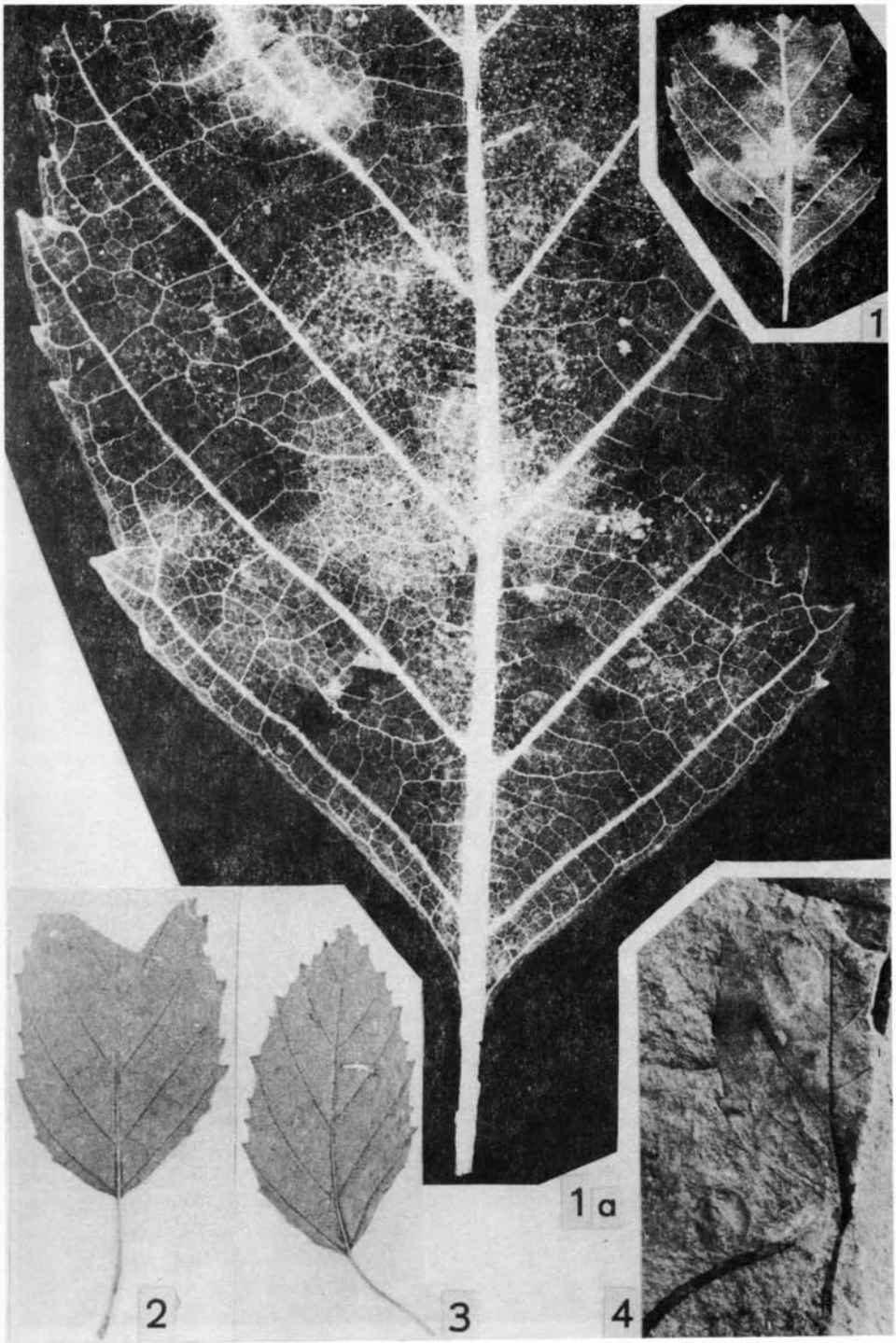

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Plate 5

Betula plioplatyptera sp. nov.

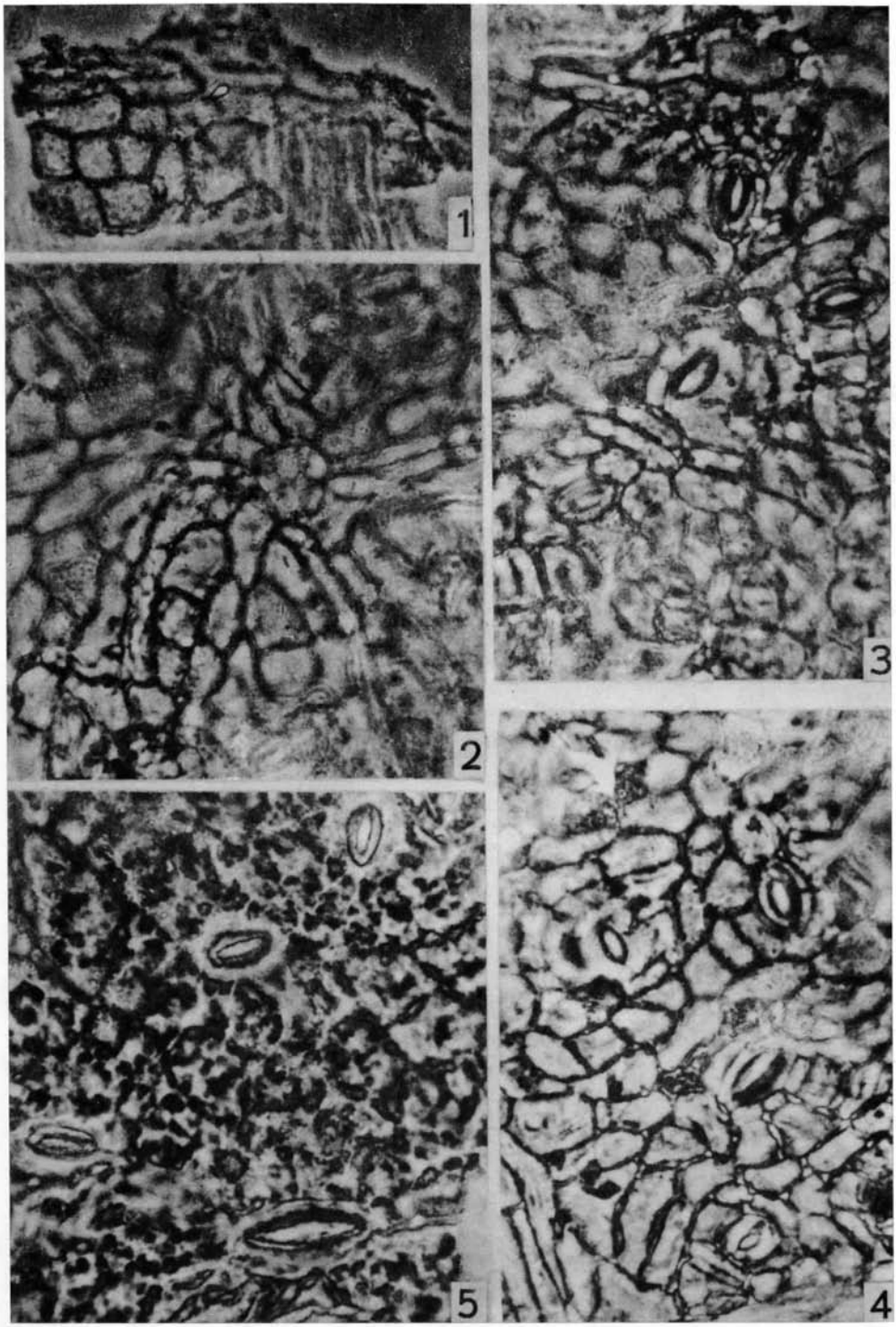
1. Upper epidermis, specimen No MZ.VII/67/0/20, x 600
2. Lower epidermis, multicellular trichome base, specimen No MZ.VII/67/0/24, x 600
3, 4. Lower epidermis, stomata, specimen No MZ.VII/67/0/24

Betula platyphylla Suk.

5. Lower epidermis, stomata; China, leg. det. M. P. Pietrov LE

1–5 – phot. A. Hummel

Plate 5



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Acta Palaeobot. 31 (1,2)

Plate 6

Betula subpubescens Goepp.

1. Specimen No MZ.VII/67/0/29, x 1
2. Specimen No MZ.VII/67/0/16, x 1

2a. Enlargement of the leaf fragment, x 4

3. Specimen No MZ.VII/67/0/28, x 1
4. Specimen No MZ.VII/67/0/59, x 1

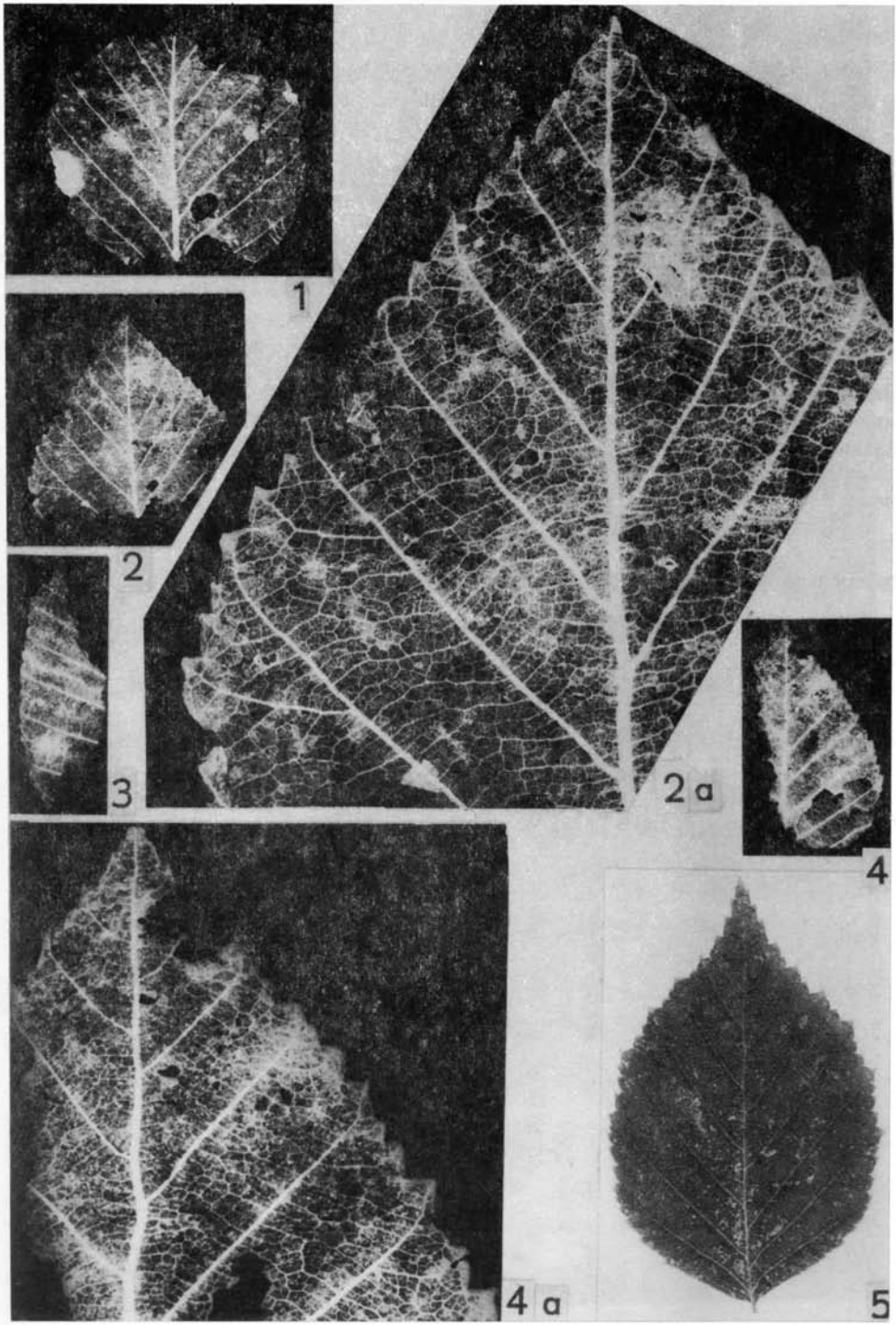
4a. Enlargement of the leaf fragment, x 4

Betula pubescens Ehrh.

5. Freiberg, coll. C. Baenitz 13924 W

1–4 – phot. M. Kleiber

Plate 6



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Acta Palaeobot. 31 (1,2)

Plate 7

Betula subpubescens Goepp.

1. Specimen No MZ.VII/67/0/73, x 1
2. Specimen No MZ.VII/67/0/63, x 1

2a. Enlargement of the leaf, x 4

3. Specimen No MZ.VII/67/0/32, x 1
4. Specimen No MZ.VII/67/0/68, x 1

Betula pubescens Ehrh.

5. Osobowice near Wrocław, leg. J. Sibilski 04553 W

Betula ermanii Cham.

6. Japan, near Hakodate, coll. Dr. Albrecht, LE

Betula schmidtii Regel.

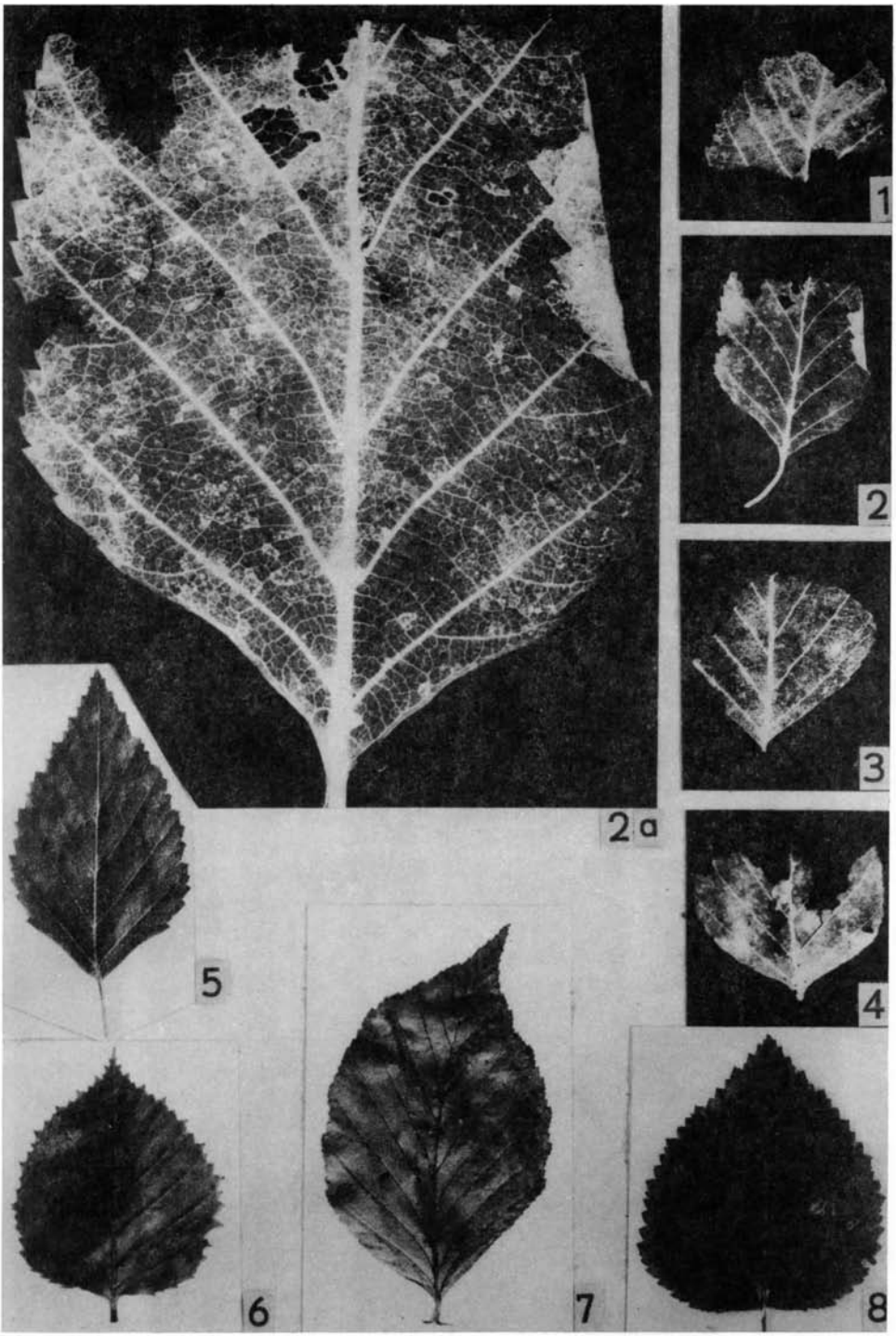
7. Japan, Tochigi near the Kobu Shrine, leg. H. Kanai 6139 LE

Betula pubescens Ehrh.

8. Zubrza near Lwów, coll. R. Lajos 23735 W

1–4 – phot. M. Kleiber

Plate 7



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Acta Palaeobot. 31 (1,2)

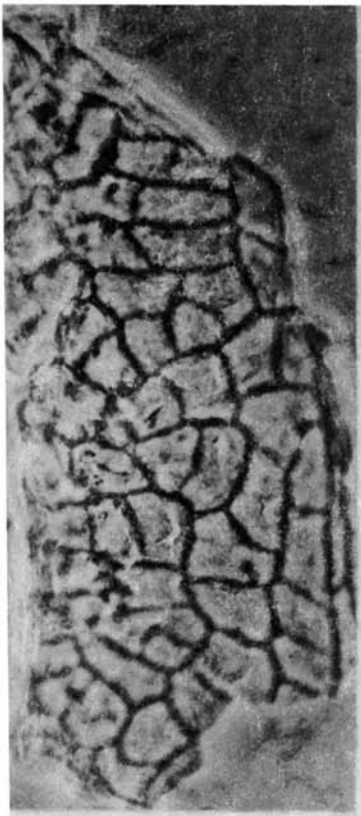
Plate 8

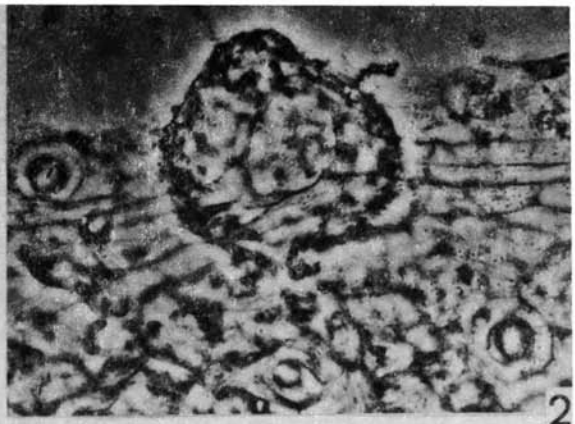
Betula subpubescens Goepp.

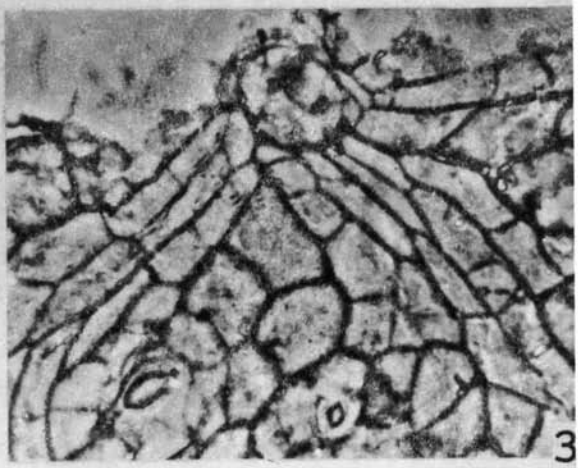
1. Upper epidermis, specimen No MZ.VII/67/0/59, x 600
2. Lower epidermis, peltate gland, specimen No MZ.VII/67/0/68, x 600
3. Lower epidermis, six-celled hair base, specimen No MZ.VII/67/0/28, x 600
4. Lower epidermis, stomata, specimen No MZ.VII/67/0/68, x 600
5. Lower epidermis, heterostoma, specimen No MZ.VII/67/0/59, x 600

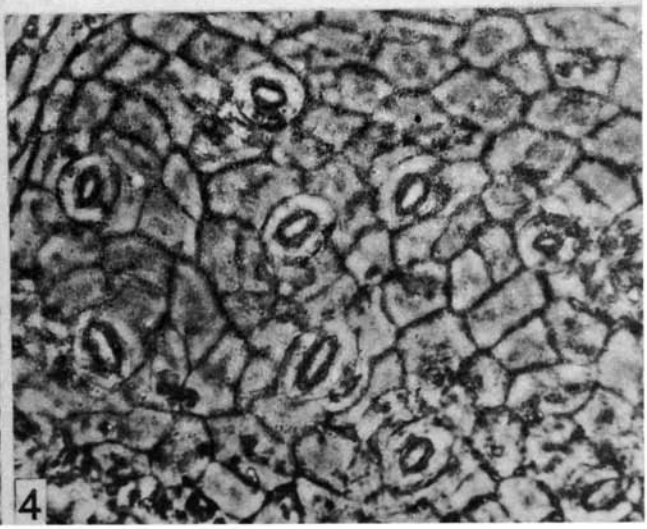
phot. A. Hummel

Plate 8









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Acta Palaeobot. 31 (1,2)

Plate 9

Betula schmidtii Regel.

1. Lower epidermis, stomata, x 600; Japan, near Hakodate, coll.Dr. Albrecht LE
2. Lower epidermis, peltate gland, x 600, ibidem

Betula sp.

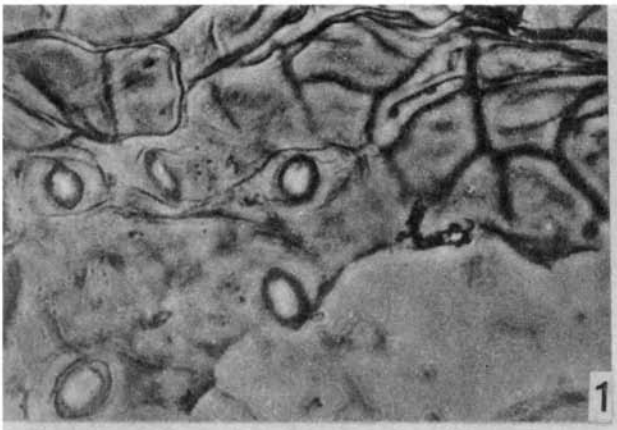
3. Specimen No MZ.VII/67/0/41, x 1
4. Specimen No MZ.VII/67/0/50, x 1

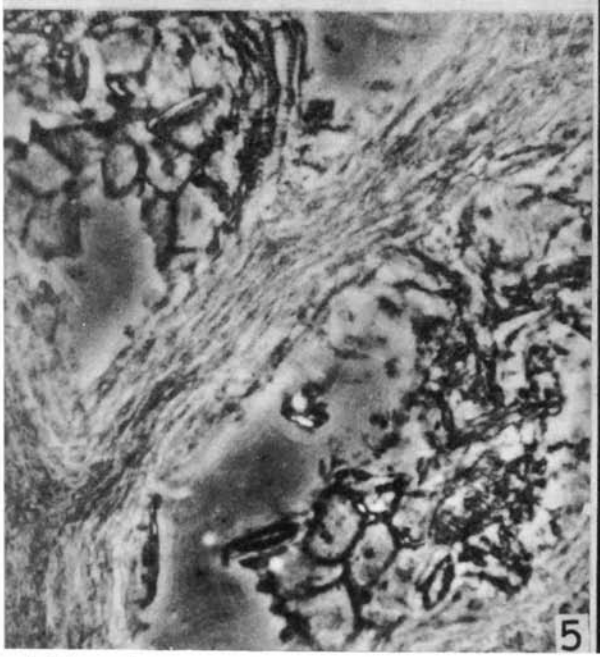
4a. Enlargement of the leaf fragment, x 4

5. Lower epidermis, specimen No MZ.VII/67/0/41, x 600

1, 2, 5 – phot. A. Hummel
3, 4 – phot. M. Kleiber

Plate 9





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Acta Palaeobot. 31 (1,2)

Plate 10

Carpinus grandis Ung. emend. Heer

1. Specimen No MZ.VII/67/0/49, x 1
2. Specimen No MZ.VII/67/0/12, x 1
3. Specimen No MZ.VII/67/0/45, x 1

3a. Enlargement of the leaf fragment, x 4

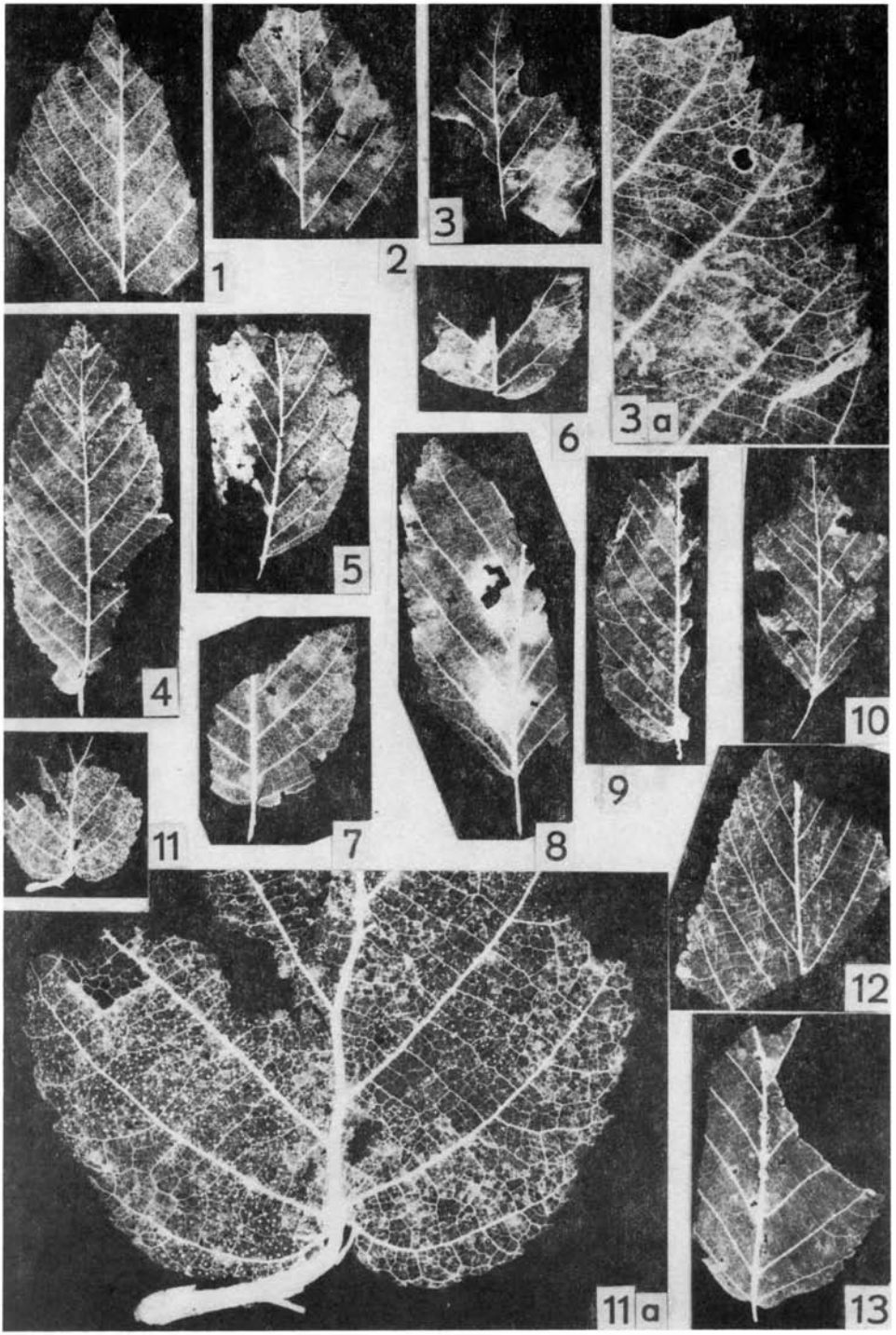
4. Specimen No MZ.VII/67/I/64, x 1
5. Specimen No MZ.VII/67/0/57, x 1
6. Specimen No MZ.VII/67/II/14, x 1
7. Specimen No MZ.VII/67/I/33, x 1
8. Specimen No MZ.VII/67/0/9, x 1
9. Specimen No MZ.VII/67/0/4, x 1
10. Specimen No MZ.VII/67/0/35, x 1
11. Specimen No MZ.VII/67/I/37, x 1

11a. Enlargement of the leaf base, x 4

12. Specimen No MZ.VII/67/I/69, x 1
13. Specimen No Mz.VII/67/0/48, x 1

phot. M. Kleiber

Plate 10



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Acta Palaeobot. 31 (1,2)

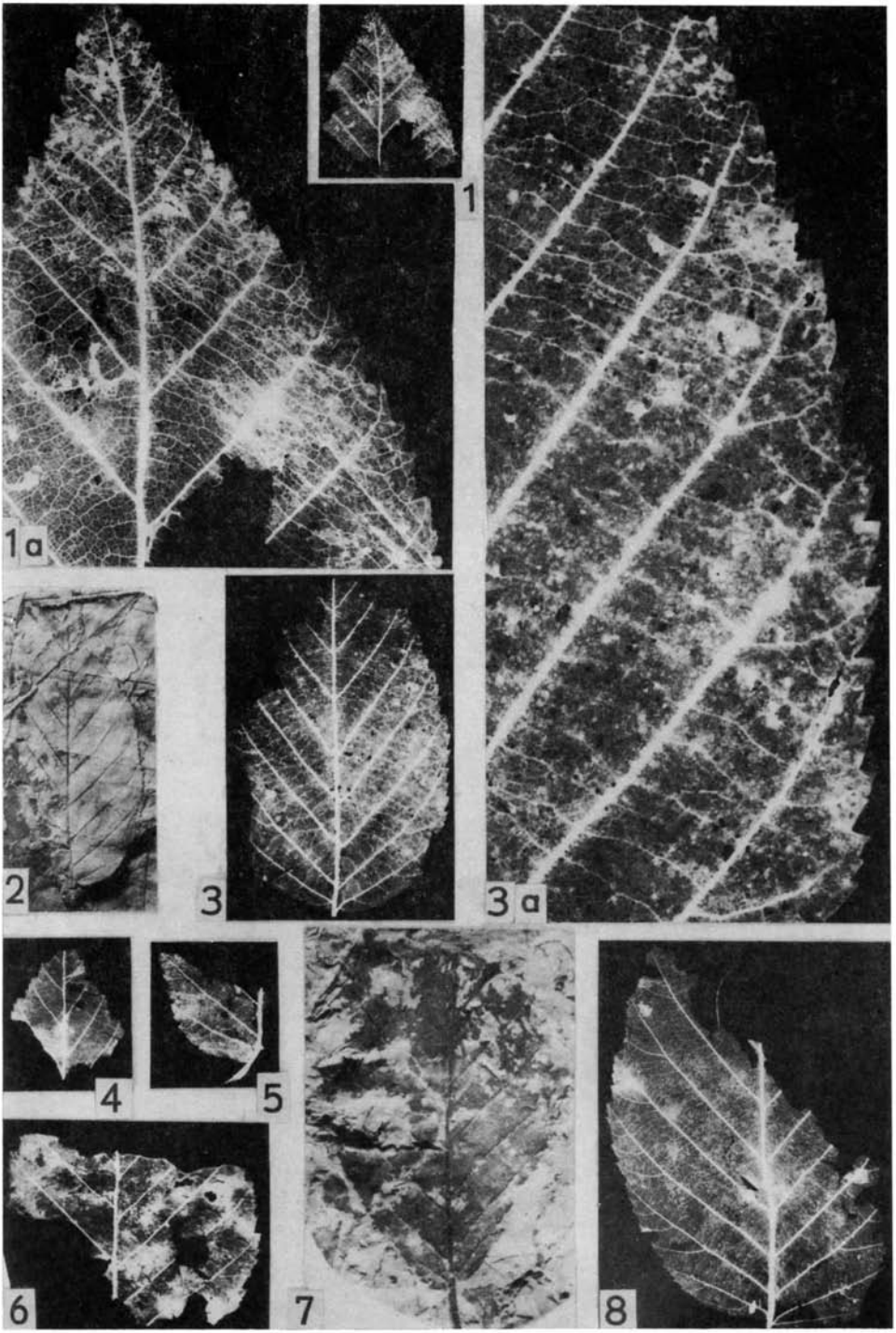
Plate 11

Carpinus grandis Ung. emend. Heer

1. Specimen No MZ.VII/67/0/66, x 1
1a. Enlargement of the leaf, x 4
2. Specimen No MZ.VII/66/8/79 b, x 1
3. Specimen No MZ.VII/67/I/68, x 1
3a. Enlargement of the leaf margin, x 4
4. Specimen No MZ.VII/67/I/30, x 1
5. Specimen No MZ.VII/67/0/30, x 1
6. Specimen No MZ.VII/67/0/37, x 1
7. Specimen No MZ.VII/66/8/193, x 1
8. Specimen No MZ.VII/67/I/2, x 1

phot. M. Kleiber

Plate 11



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Acta Palaeobot. 31 (1,2)

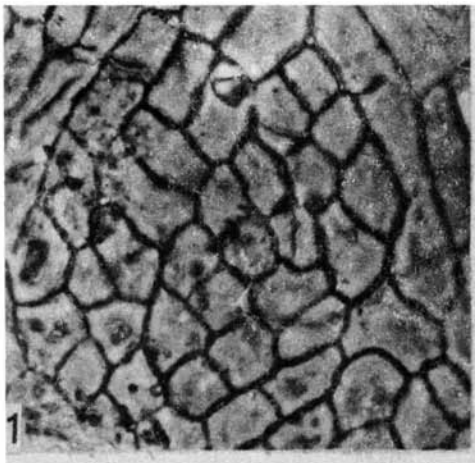
Plate 12

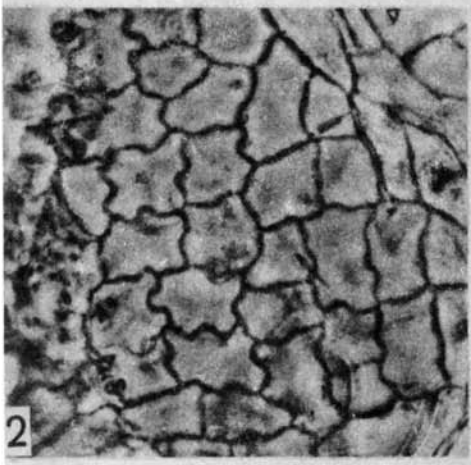
Carpinus grandis Ung. emend. Heer

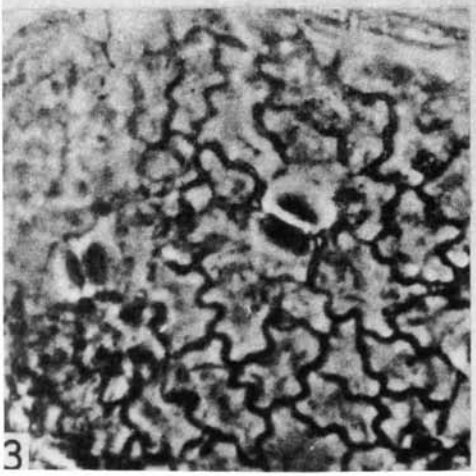
1, 2. Upper epidermis, specimen No MZ.VII/67/I/30, x 600
3. Lower epidermis, stomata, specimen No MZ.VII/67/I/69, x 600
4. Lower epidermis, stomata, specimen No MZ.VII/67/0/30, x 600
5. Lower epidermis, stomata, specimen No MZ.VII/67/I/68, x 600

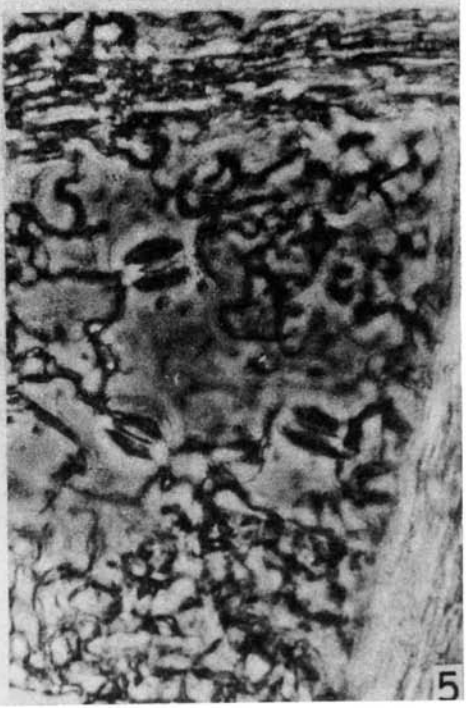
phot. A. Hummel

Plate 12









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Acta Palaeobot. 31 (1,2)

Plate 13

Carpinus grandis Ung. emend. Heer

1. Lower epidermis, glandular hair, specimen No MZ.VII/67/0/90, x 600
2. Lower epidermis, bicellular trichome base, specimen No MZ.VII/67/0/37, x 600

Carpinus caucasica Grossheim

3. Lower epidermis, stomata, x 600; Caucasus, near Ritsa lake leg. A. Hummel WA ME

Carpinus grandis Ung. sensu Berger – involucres

4. Specimen No MZ.VII/66/8/191, x 1

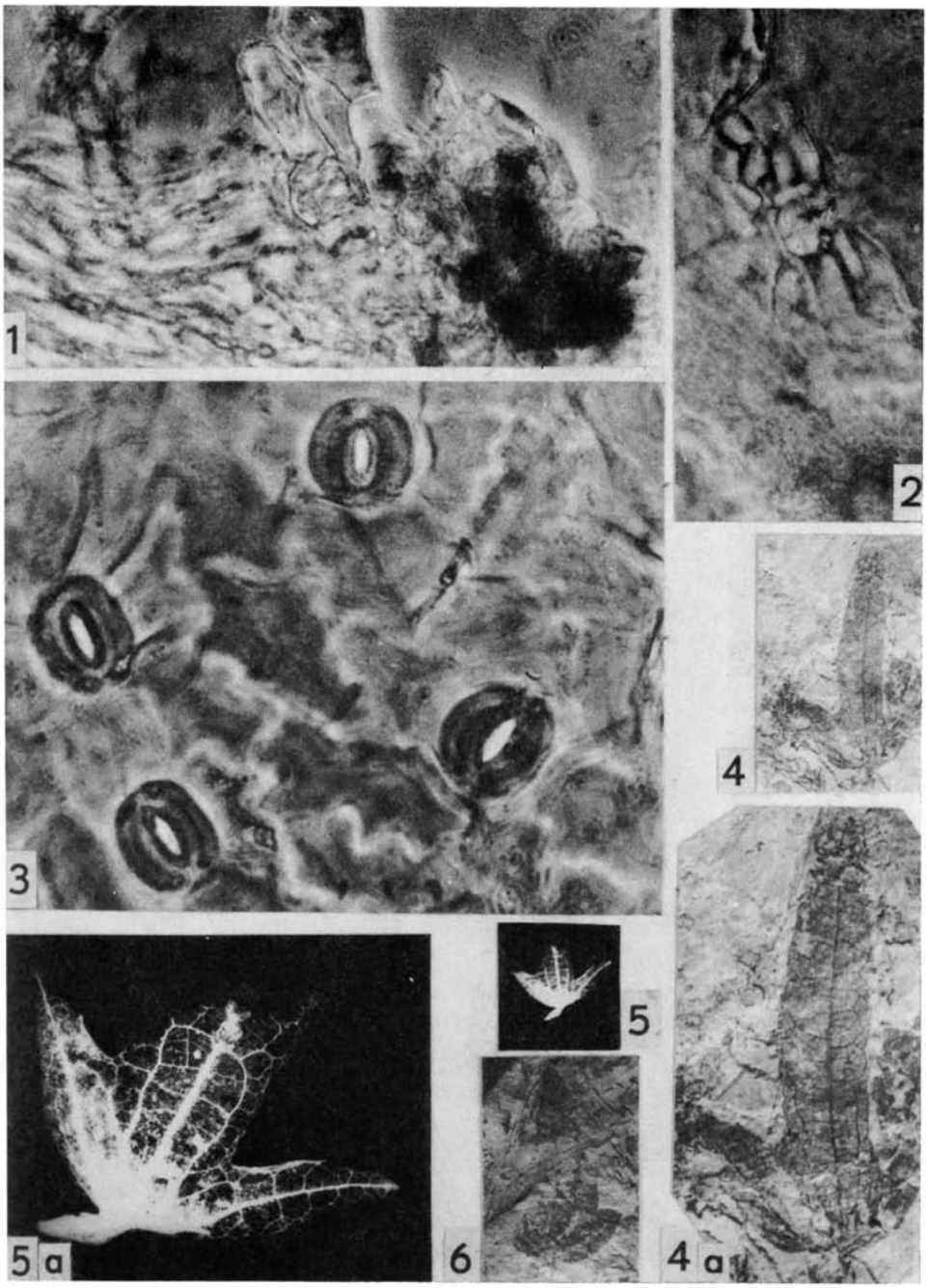
4a. The same, x 2

5. Specimen No MZ.VII/67/0/83, x 1

5a. The same, x 4

6. Specimen No MZ.VII/66/8/246 a, x 1

1–3 – phot. A. Hummel
4–6 – phot. M. Kleiber



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Acta Palaeobot. 31 (1,2)

Plate 14

Corylus avellana L. fossilis

1. Upper epidermis, specimen No MZ.VII/67/0/31, x 600
2. Lower epidermis, stomata (X), specimen No MZ.VII/67/31, x 600
3. Specimen No MZ.VII/66/8/284, x 1

3a. Enlargement of the leaf, x 2

4. Specimen No MZ.VII/67/0/31, x 1

4a. Enlargement of the leaf, x 4

1, 2 – phot. A. Hummel
3, 4 – phot. M. Kleiber

Plate 14

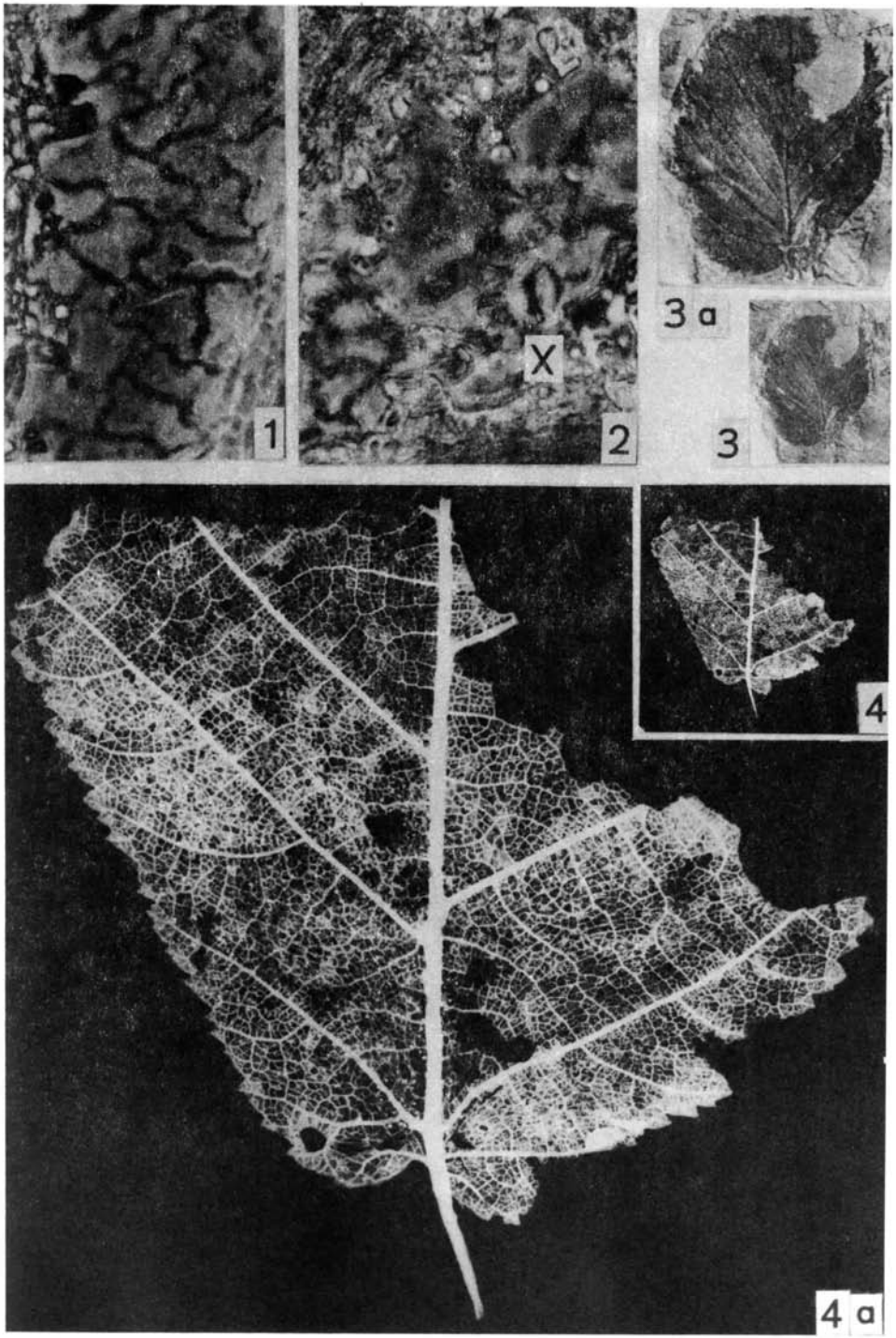

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Plate 15

Ostrya carpinifolia Scop. fossilis

1. Specimen No MZ.VII/67/0/33, x 1
2. Specimen No MZ.VII/67/0/1, x 1

2a. Enlargement of the leaf margin, x 4

3. Specimen No MZ.VII/67/II/4, x 1

3a. Enlargement of the leaf margin, x 4

4. Specimen No MZ.VII/67/I/65, x 1

4a. Enlargement of the leaf, x 4

5. Specimen No MZ.VII/67/I/38, x 1

phot. M. Kleiber

Plate 15

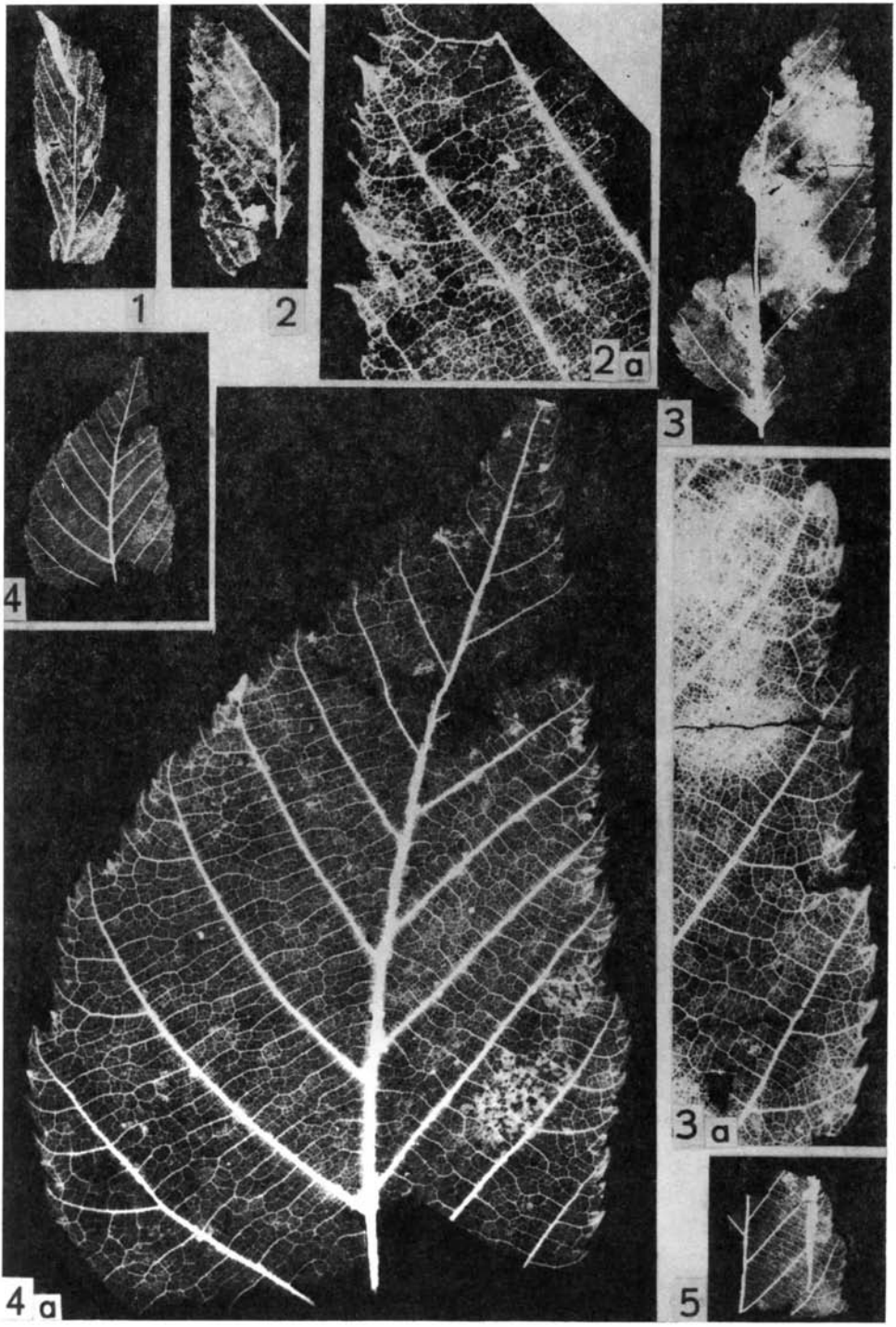

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Plate 16

Ostrya carpinifolia Scop. fossilis

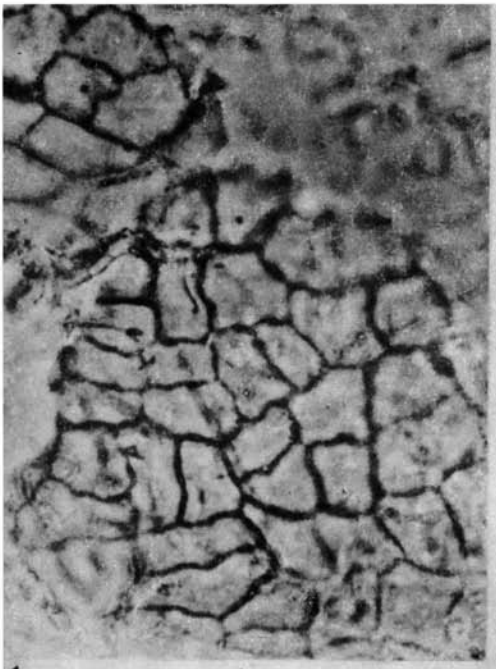
1. Upper epidermis, specimen No MZ.VII/67/I/38, x 600
2. Lower epidermis, small circular trichome base, specimen No MZ.VII/67/I/65, x 600
3. Lower epidermis, stomata, specimen No MZ.VII/67/I/65, x 600

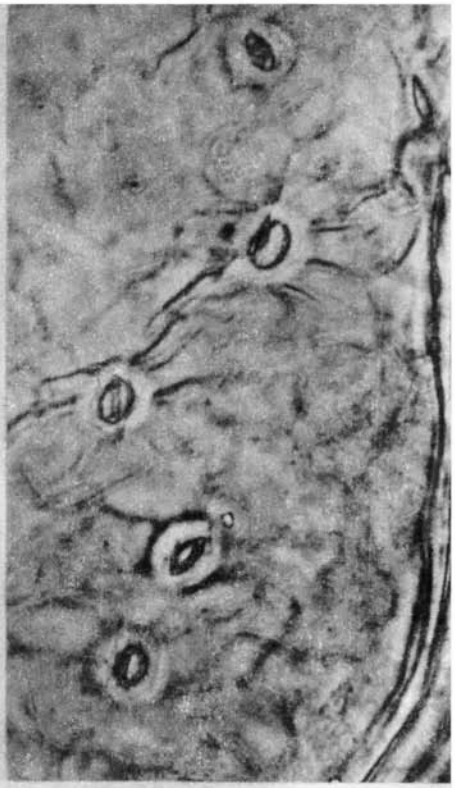
Ostrya carpinifolia Scop.

4. Lower epidermis, stomata, x 600; Georgia, leg. det. A. A. Kolakovsky, Herb. of Bot. Garden Sukhumi

phot. A. Hummel

Plate 16





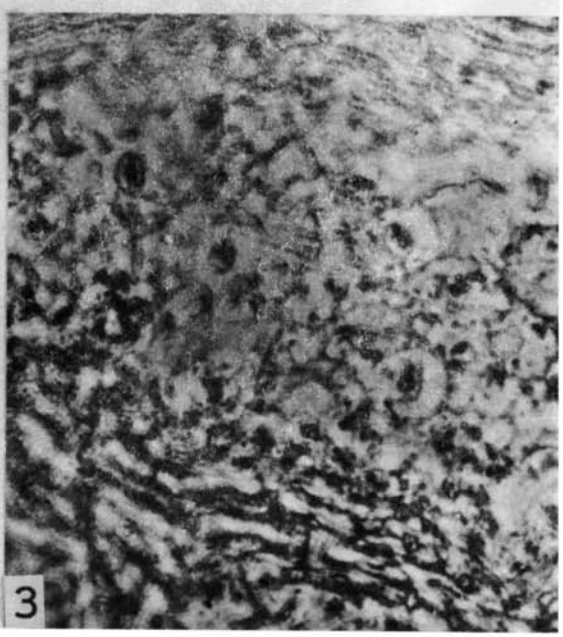


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Plate 17

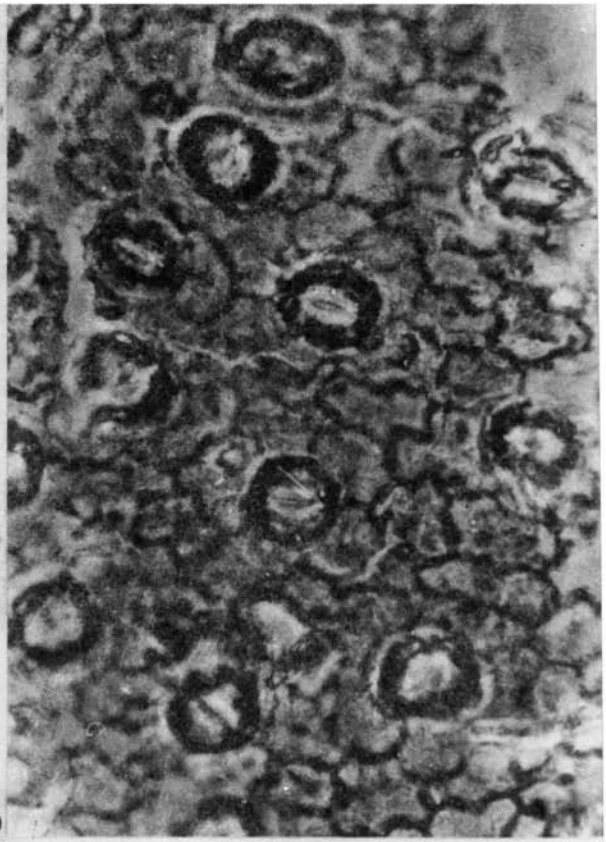
Phyllites sp. 3

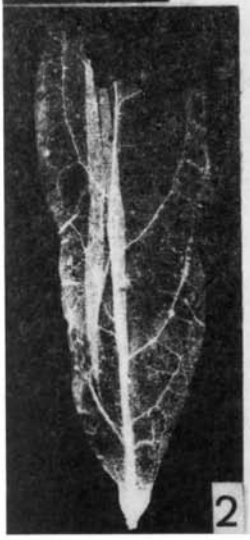
1. Specimen No MZ.VII/67/0/7, x 1
1a. Enlargement of the leaf, x 3,5
1b. Lower epidermis, stomata, x 600

Phyllites sp. 4

2. Specimen No MZ.VII/67/I/81, x 1
2a. Upper epidermis, x 600

1, 1a, 2 – phot. M. Kleiber
1b, 2a – phot. A. Hummel





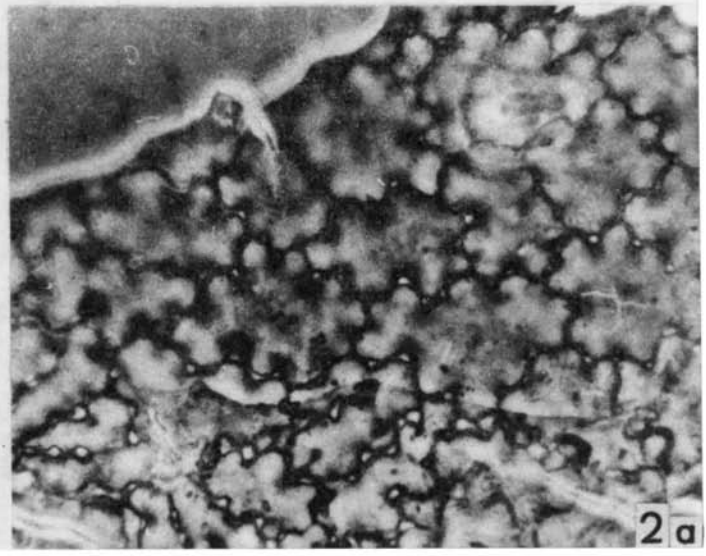


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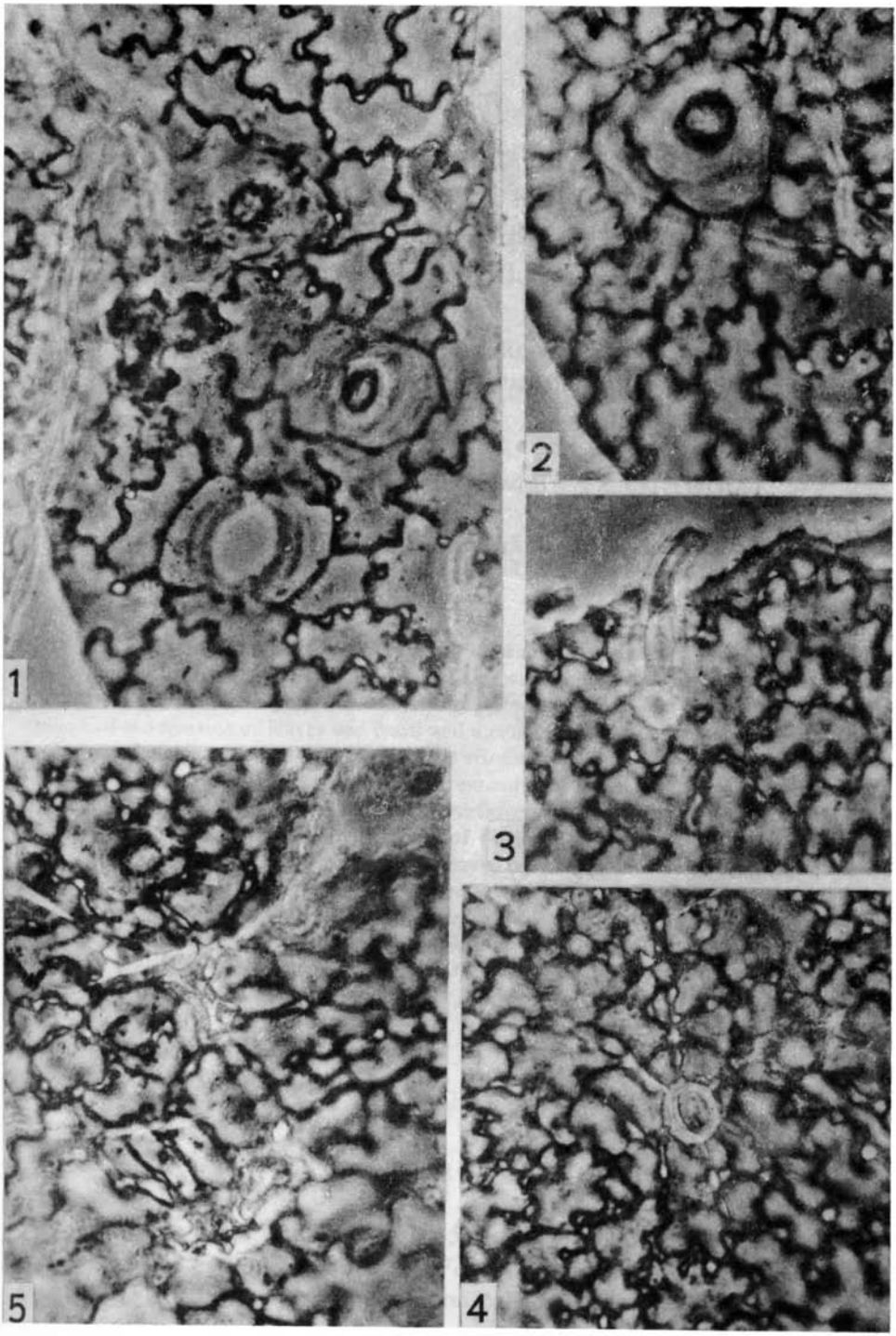
Plate 18

Phyllites sp. 4 – specimen No MZ.VII/67/I/81

1, 2. Lower epidermis, stomata, x 600
3. Lower epidermis, uniseriate hair, x 600
4. Lower epidermis, trichome base, x 600
5. Sclereids, x 600

phot. A. Hummel

Plate 18



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