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Laurus abchasica (Kolakovsky & Shakryl) Ferguson from the Neogene of the Bełchatów Lignite Mine (Central Poland)

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ABSTRACT. Macromorphology and epidermal micromorphology of a leaf fragment belonging to *Laurus abchasica* (Kolakovsky & Shakryl) Ferguson from the Neogene aged deposits of the Bełchatów Lignite Mine (Central Poland) are described. *Litsaeophyllum miocenicum* Juchniewicz from Turów is revised and also assigned to *Laurus abchasica*. The fossil record of other Lauraceae leaves from the Palaeogene and Neogene deposits of Poland are summarized and briefly discussed.

KEY WORDS: *Laurus abchasica*, Lauraceae, macromorphology, epidermal micromorphology, Early Miocene, Bełchatów Lignite Mine, Poland

INTRODUCTION

Leaves of fossil members of the Lauraceae Jussieu are frequently found in the Tertiary deposits of Europe. The occurrence of laurels in fossil floras is very important from a palaeovegetational, palaeogeographical and also a palaeoclimatical point of view. From the Lower and Middle Miocene deposits of Poland, Lauraceae leaves were reported several times (Heer 1869, Kräusel 1920, Kownas 1956, Raniecka-Bobrowska 1957, 1962, Il'inskaya 1964, Juchniewicz 1975, Czeczott & Skirgiełło 1980, Łańcucka-Środoniowa & Zastawniak 1997, Zastawniak & Worobiec 1997, Głazek & Zastawniak 1999, Worobiec 2003a). However, only in exceptional cases were they examined with use of cuticular analysis, mostly due to an absence of preserved cuticles. From the Lower Miocene deposits of the Bełchatów Lignite Mine (Central Poland) two Lauraceae leaf species with preserved cuticles have been recently described (Worobiec 2003a). The leaf described here was found in 1996 in a drill core from the Bełchatów Lignite Mine. The excellent preservation of this leaf is the basis for a detailed description. The occurrence of Lauraceae leaves in the Neogene deposits of the Bełchatów Lignite Mine presents the opportunity to discuss the Lauraceae leaf record from Tertiary deposits of Poland.

GEOLOGY

The Bełchatów Lignite Mine is situated in the southern part of the central European Lowlands, in Central Poland, approx. 15 km south of Bełchatów (Fig. 1). In this area lignite seams occur within a series of tectonic depressions named the Kleszczów Graben (Stuchlik et al. 1990). The graben is filled with 200–250 m (locally over 600 m) thick Cenozoic deposits (Gotowała & Hałuszczak 1999). As a result of geological and palaeontological studies carried out on the Bełchatów Lignite Mine outcrop, a synthetic lithostratigraphical profile of the Neogene deposits filling the Kleszczów Graben has been established (Stuchlik et al. 1990, Czarnecki et al. 1992, Stuchlik & Szynkiewicz 1998, Szynkiewicz 2000, Matl 2000). After Czarnecki et al. (1992) and Matl

Fig. 1. Location of the Bełchatów Lignite Mine in Poland

(2000), four main lithological units are distinguished (Fig. 2): subcoal unit (PW), coal unit (W) including the main seam (PG) and seams B and C, clayey-coal unit (I-W) with seam A, and the youngest clayey-sandy unit (I-P).

The fossil leaf of *Laurus abchasica* was found within the drill core taken from borehole No. 1294/B in the Bełchatów Lignite Mine. The coaly silt core sample comes from 35.2–35.3 m below sea level and lies nearly 30 m above the main seam (PG), and below coal seam A. Its stratigraphical position corresponds to the lowermost part of clayey-coal unit (I-W). The clayey-coal unit (I-W) comprises gravel, sand, silt, clay, lacustrine limestone layers, and coal seam A. Within the clayey-coal unit there is the paratonstein (tuffitic) horizon TS-2 (Wagner 2000). Using fission track (FT) method, TS-2 horizon that lies in the roof or near-roof parts of seam A, was first dated at 16.5 ± 1.3 Ma BP (Burchart 1985) and later at 17.05 ± 0.69 Ma BP (Burchart et al. 1988). From deposits overlain by seam A, remains of mammals (locality Bełchatów B) indicating Neogene mammal zone MN5 (Late Karpatian – Early Badenian) or MN 5/6 (Badenian) were reported (Kowalski 1993, Nadachowski 2001). Results of carpological investigations from the lower part of the clayey-coal unit (I-W) allow the correlation of these sediments with the Karpatian (Stuchlik et al. 1990). The stratigraphical position of the core sample (considerably below TS-2 horizon) suggests latest Early Miocene (Late Karpatian) or less probably, lowermost Middle Miocene (Early Badenian) age for the horizon that contains the *Laurus abchasica* leaf.

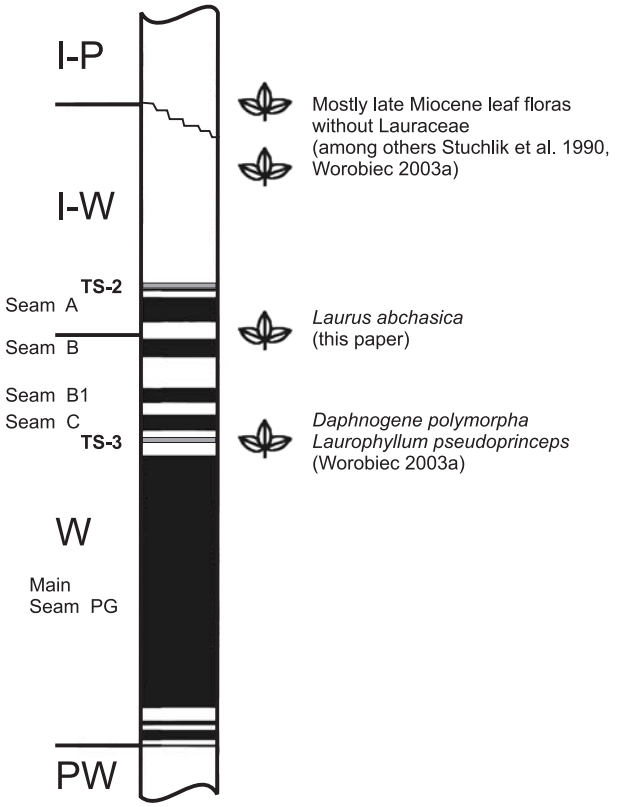

Fig. 2. Scheme of the geological profile of the Neogene deposits of the Bełchatów Lignite Mine (after Worobiec 2001, considerably changed). **TS-3** – paratonstein TS-3 (vel denoted as TS-4, Wagner 2000), fission track dated at 18.1 ± 1.7 Ma BP (Burchart 1985) and at 17. 25 ± 0.4 Ma BP (Burchart et al. 1988); **TS-2** – paratonstein TS-2, fission track dated at 16.5 ± 1.3 Ma BP (Burchart 1985) and at 17.05 ± 0.69 Ma BP (Burchart et al. 1988); **PW –** subcoal unit, **W** – coal unit, **I-W** – clayey-coal unit, **I-P** – clayey-sandy unit

MATERIAL AND METHODS

The leaf of *Laurus abchasica* is preserved as adpression (impression and compression, see Shute & Cleal 1987), which were separated. The leaf impression was slowly dried. To isolate the leaf compression from the counterpart the chemical treatment described by Worobiec (2003b) was used. Small fragments of the isolated leaf compression were used for cuticular analysis. They were macerated using a solution of NaClO (a commercial bleach, called „Bielnar") and finally mounted in glycerine jelly. Two microscopic slides of leaf cuticles were prepared. Macromorphological description is based on nomenclature proposed by Hickey (1979) and micromorphological structures are described following Dilcher (1974) and Wilkinson (1979). The method of measuring the size of micromorphological structures depended on their shape. For regular, round or broadly elliptical structures, their diameter was measured, while in tetragonal shape their length and width. Structures with irregular or variable shape (mainly epidermal cells) had their longest dimension measured (size). The drawing was made using a Carl Zeiss stereomicroscope with *camera lucida* attachment. Macrophotography, bright field and phase contrast microphotography of the cuticle

were made using NIKON Eclipse E400 microscope fitted with NIKON Coolpix 995 and NIKON DS-5M-U1 digital cameras.

SYSTEMATIC PART

Lauraceae Jussieu

Laurus L.

Laurus abchasica (Kolakovsky & Shakryl) Ferguson

Pl. 1, figs 1–6, Pl. 2, figs 1–8

1958 *Laurophyllum abchasicum* Kolakovsky & Shakryl, Kolakovsky, p. 346, pl. 7, figs 1–3, pl. 10, figs 4–8.

1974 *Laurus abchasica* (Kolakovsky & Shakryl) Ferguson comb. nov., Ferguson, p. 64–69, Fig. 7: A-H, Fig. 8: A-D, Fig. 9: A-D, Fig. 10.

1975 *Litsaeophyllum miocenicum* sp. nov., Juchniewicz, p. 81–82, pl. 10, figs 1, 2.

Material. KRAM-P 223: 1

Description.

Macromorphology**.** One leaf fragment preserved (impression and compression). Leaf impression about 4.2 cm long and 2.4 cm wide (presumably width of the whole leaf about 2.6 cm). The isolated compression fragment measures 1.3 × 1.0 cm. Leaf margin entire. Venation brochidodromous, only one pair of secondary veins in the apical part of the leaf preserved, forming an angle of about 60° with the primary vein. Secondary veins, widely spaced, curving upward interconnecting in loops (near the leaf margin). Tertiary venation weakly percurrent or reticulate. Higher-order venation more or less orthogonal reticulate. Areoles well developed, often tetragonal, 0.25–0.44 mm in size. Veinlets usually absent, if present, simple. Marginal ultimate venation forming a fimbrial vein.

Micromorphology. Adaxial epidermis comprises isodiametric or slightly elongated cells, 19.7–34.4 μm in size. Anticlinal cell walls of moderate thickness, usually strongly Ω-undulate. Over the veins anticlinal cell walls usually less undulate and more elongated, more or less oblong. On the adaxial epidermis one solitary, strongly damaged trichome (?) was found over the vein. Abaxial epidermis consists of isodiametric or frequently elongated cells, 19.7–34.4 μm in size. Anticlinal cell walls irregularly undulate and considerably thicker than adaxial epidermis. Leaf hypostomatic. Stomata 19.7–24.6 μm in size (dimension measured between stomatal poles), paracytic, distinctly cutinized and of characteristic round-rhomboid (frequently distinctly rhomboidal) shape. Outer stomatal ledge distinctly cutinised but with indistinct outer boundaries (as seen in light microscope). Outer stomatal ledge aperture usually arched and rather thin, 12.3–14.8 μm long and always less than 2.5 μm wide. In the leaf mesophyll numerous idioblast secretory cells (filled with oil-like remnants) are preserved, and are more or less round in shape, sometimes elongate, 22.1–39.4 μm in diameter (Pl. 1, figs 5–6, Pl. 2, figs 6, 8). Under the microscope long and parallel ridge-like epidermal elevations are visible along the leaf margin (Pl. 1, fig. 4).

Remarks**.** Rhomboidal shape of the stomata and strongly undulate anticlinal cell walls (especially Ω-undulate walls of adaxial epidermis) are characteristic of leaves of the fossil laurel *Laurus abchasica* (Kolakovsky & Shakryl) Ferguson (Ferguson 1974). For the first time this species was described by Kolakovsky (1958) from the Pliocene flora of Duab as *Laurophyllum abchasicum* Kolakovsky & Shakryl. Kvaček (1971) agreed with the opinion of Kolakovsky (1958) that *Laurophyllum abchasicum* in respect of macromorphology and structure of the epidermis is most similar to the leaves of the extant genus *Laurus,* but he avoided confirming this determination. On the basis of detailed analysis of macromorphology and micromorphology of *Laurophyllum abchasicum* and the two recent species *Laurus nobilis* L. and *L. azorica* (Seub.) Franco (= *Laurus canariensis* Webb & Berth. non Willd.), Ferguson (1974) considered that almost certainly *Laurophyllum abchasicum* belongs to the genus *Laurus*. He introduced the new combination *Laurus abchasica* (Kolakovsky & Shakryl) Ferguson to the fossil leaves discussed and provided a detailed macromorphological and micromorphological description. Ferguson (op. cit.) rejected all taxonomical determinations of earlier described fossil leaves as belonging to the genus *Laurus* based only on macromorphology without an accompanying analysis of epidermal structure.

According to Ferguson (1974), both recent *Laurus nobilis* and *L. azorica* are closely related to the fossil *L. abchasica*. *Laurus nobilis* and *L. azorica* are much the same in respect of macromorphology and micromorphology. Moreover Ferguson (1974) found that they differ only in the presence/absence of leaf tomentum in young leaves (*L. nobilis*: glabrous, *L. azorica*: pubescent) and in chromosome number (*L. nobilis* 2n = 42, *L. azorica* 2n = 36). Regarding the epidermis structure *Laurus abchasica* is little more similar to *L. azorica* (Kolakovsky 1958, Ferguson op. cit.).

Laurus abchasica has been reported mainly from Early to Middle Miocene localities of Central Europe, e.g. Hrádek n. Nisou (Kvaček 1971), Kreuzau (Ferguson 1971, 1974), Wackersdorf (Knobloch & Kvaček 1976), Cypris Shale (Bůžek et al. 1996), Mydlovary Formation (Knobloch & Kvaček 1996), Oberdorf (Kovar-Eder & Meller 2001), and from the Late Miocene of Valea de Cris (Givulescu 1975), Mataschen (Kovar-Eder & Hably 2006), and the Late Miocene/Pliocene of Duab in Abkhasia (Kolakovsky 1958). Kovar-Eder & Meller (2001) considered this laurel to be restricted to the Neogene but more recently Kvaček (2004) determined leaves of *Laurus abchasica* making "cuticular" revision of the Early Oligocene flora of Flörsheim (Germany) earlier described by Engelhardt (1911). Kvaček (op. cit.) distinguishes *L. abchasica* from leaves of another Paleogene member of the Lauraceae family, *Laurophyllum fischkandelii* Kunzmann & Walther described by Kunzmann & Walther (2002) from the Late Eocene of the Weisselster Basin on the basis of differences in stomatal complex structure.

Juchniewicz (1975) described a new taxon of *cuticulae dispersae* from the Lower Miocene deposits of Turów as *Litsaeophyllum miocenicum* Juchniewicz. She pointed out certain similarity in epidermal composition of this species to *Laurus abchasica* (similar rhomboidal stomata) and *Laurophyllum villense* (Weyland & Kilpper) Bůžek & Kvaček (common idioblast secretory cells). However, Juchniewicz (op. cit.) arrived at the conclusion that other features of the epidermal structure of *Litsaeophyllum miocenicum* were distinct from the genus *Laurus*. Finally she compared *L. miocenicum* with the epidermis of recent *Litsea fulva* Vill. On the basis of reinvestigation of the cuticular slides of *L. miocenicum* (holotype – specimen no. 402, and specimen no. 401 stored in the Museum of the Earth, Polish Academy of Sciences, Warszawa) the present author is of the opinion that *Litsaeophyllum miocenicum* most probably represents the abaxial (and probably adaxial) leaf epidermis of *Laurus abchasica*, and was erroneously compared to *Litsea fulva* Vill. *Litsaeophyllum miocenicum* from Turów has similar areoles (0.20–0.49 mm in size), absent or rarely present simple veinlets, strongly undulate walls of epidermal cells and characteristic rhomboidal shape of stomata (Pl. 2, figs 7, 8). *Litsaeophyllum miocenicum* from Turów differs from *Laurus abchasica* from Bełchatów in the size of stomata (*L. miocenicum* from Turów: 24.6–32.0 µm, *Laurus abchasica* from Bełchatów: 19.7–24.6 µm) and less in size of idioblast secretory cells (*L. miocenicum* has them somewhat larger). However, the size of stomata of *L. miocenicum* corresponds to the variability range of the stomata size of *Laurus abchasica* described earlier, e.g. 12.6–35.1 µm from Kreuzau (Ferguson 1974), and 15–32 µm from Wackersdorf (Knobloch & Kvaček 1976). The differences discussed most probably are due to the scarcity of investigated cuticular material (only single leaves from Turów and Bełchatów).

Besides *Laurus abchasica*, *Daphnogene polymorpha* (Al. Braun) Ettingshausen, and *Laurophyllum pseudoprinceps* Weyland & Kilpper were earlier reported from the Lower Miocene deposits of the Bełchatów Lignite Mine (Worobiec 1995, 2003a). Unfortunately, *Laurus abchasica* from Bełchatów was found in slightly younger deposits (Fig. 2) than *Daphnogene polymorpha* and *Laurophyllum pseudoprinceps* (Ottnangian-Karpatian, Worobiec 2003a) and the palaeovegetation and palaeoclimate reconstructed from accompanying plant remains cannot serve as background for *L. abchasica*. However, reconstruction of palaeoecology of *L. abchasica* can be performed on the basis of comparison with other Miocene European occurrences of *L. abchasica* as well as on the results of palaeozoological investigations of the *L. abchasica* bearing deposits from the Bełchatów Lignite Mine. In the Early and Middle Miocene plant assemblages from Wackersdorf (Knobloch & Kvaček 1976), Cypris Shale (Bůžek et al. 1996), Mydlovary Formation (Knobloch & Kvaček 1996), and Oberdorf (Kovar-Eder & Meller 2001) *L. abchasica* was found with abundant plants representing

remains of Evergreen Broad-Leaved Forests and Mixed Mesophytic Forests. *L. abchasica* probably was a component of mesophytic vegetation in which thermophilous evergreen elements typical of Younger Mastixioid assemblages sensu Mai (1964) with Lauraceae, Mastixiaceae, evergreen Fagaceae (*Trigonobalanopsis*), *Distylium*, *Engelhardia*, and *Symplocos* dominated (Knobloch & Kvaček 1976, Meller et al. 1999, Kovar-Eder & Meller 2001, Kovar-Eder et al. 2001). Deciduous taxa were also present, e.g. *Acer*, *Alnus*, *Carya*, *Quercus*, as well as conifers, e.g. *Pinus*. Climatic conditions corresponded to a subtropical humid climate with mean annual temperature about 15°C, coldest month mean above 0°C with nearly frostfree winter and mean annual precipitation of 1000 mm or more (Knobloch & Kvaček 1976, 1996, Bůžek et al. 1996).

Results of investigations of mammals from the locality Bełchatów "B" (between seam A and B) occurring in a similar stratigraphical position as *Laurus abchasica* point to subtropical climatic conditions and show a dominance of forest elements. The lack of steppe elements among remains of small mammals indicates the absence of open environment around the Bełchatów locality (Kowalski & Rzebik-Kowalska 2002). These conclusions correspond to the palaeoecological signal of *L. abchasica* and accompanying taxa in the European record.

Occurrence. Early Miocene – Turów (as *Litsaeophyllum miocenicum* Juchniewicz, Juchniewicz 1975), Bełchatów.

REMARKS ON THE OCCURRENCE OF LAURACEAE FOLIAGE IN THE PALAEOGENE AND NEOGENE OF POLAND

Most leaves of Lauraceae reported from the Tertiary of Poland are preserved as impressions and their taxonomical position could not be re-examined using cuticular analysis. Taking into account the opinion of Kvaček (1971) that without cuticular analysis it is not possible to provide reliable specific determinations of fossil Lauraceae foliage, all lauraceous leaf taxa reported from the Tertiary of Poland based on macromorphology exclusively should be revised and untill then should be considered as doubtful. On the basis of macromorphology only the artificial morphogenus *Daphnogene* Unger (= *Cinnamomophyllum* Kräusel & Weyland and = *Cinnamomum* Schaeffer *fossil*) without specific determinations can be reliably distinguished, and can be considered as representative of Lauraceae.

Fossil leaves considered as belonging to the genus *Laurus* have been previously reported several times from Eocene deposits of Chłabówka (Central Carpathians, Kuźniar 1910), Early Miocene of Rozewie (Heer 1869), Osieczów (Raniecka-Bobrowska 1962, 1965, Piwocki et al. 2004) and Turów (Czeczott & Skirgiełło 1980), Middle Miocene deposits of Swoszowice (Unger 1849, Il'inskaya 1964). All leaf taxa of *Laurus* from the listed localities were determined without use of cuticular analysis and their assessment to *Laurus* should be considered as dubious.

Leaves of the morphogenus *Daphnogene* have been reported several times from Palaeogene and Neogene deposits of Poland. The oldest record stems from Eocene deposits of Chłabówka (Kuźniar 1910, Szafer 1958, Głazek & Zastawniak 1999). From Lower Miocene deposits leaves of *Daphnogene* were reported from Rozewie (as *Cinnamomum*, Heer 1869), Bluszczów and Dzierżysław (as *Cinnamomophyllum*, Kräusel 1920), Osieczów (as *Cinnamomophyllum* and *Daphnogene*, Raniecka-Bobrowska 1962), and Turów (as *Cinnamomophyllum,* Czeczott & Skirgiełło 1980). The Middle Miocene record of *Daphnogene* derives from two localities of the Wieliczka Formation (Krzyżanowice Formation, Late Badenian, Neogene nannoplankton zone NN6, Jasionowski & Peryt 2004, Jasionowski et al. 2004): Wieliczka Salt Mine (Łańcucka-Środoniowa & Zastawniak 1997) and Swoszowice (as *Cinnamomum*, Il'inskaya 1964).

The leaf of *Cinnamomum* (*Daphnogene*) *polymorphum* from the Upper Miocene deposits of Stare Gliwice (Szafer 1961) has been previously reconsidered and correctly identified as *Phyllites nemejci* Bůžek (see Zastawniak 1980).

Cuticular analysis of leaves of Lauraceae was performed only from three localities of Poland: Early Miocene of Turów (*cuticulae dispersae*, 6 taxa, Juchniewicz 1975), Bełchatów (3 taxa, Worobiec 2003b, this paper), and Middle Miocene of Krywałd (one taxon, Raniecka-Bobrowska 1957). The leaf of *Laurophyllum* sp. from Krywałd most probably represents *Laurophyllum pseudoprinceps* Weyland & Kilpper,

the "undulatum" type sensu Kvaček (1971). Contrary to Upper Miocene/Pliocene deposits in western Europe (e.g. Belz & Mosbrugger 1994), further Central Europe (e.g. Hably & Kvaček 1998, Kovar-Eder & Hably 2006), and southern Europe (e.g. Kvaček et al. 2002, Martinetto 2003), the deposits of this time interval lack Lauraceae foliage in Poland. As a result of the regression of the Paratethys Sea from southern Poland and the uplift of the Carpathian mountains (Gilewska 1999, Jiménez-Moreno 2006) most probably less favourable climatic conditions prevailed in the area of Poland contrary to western and southern Europe. This appears to have led to the demise of the Lauraceae in this region.

CONCLUSIONS

1) From the latest Lower Miocene deposits of the Bełchatów Lignite Mine (Central Poland) one leaf fragment of *Laurus abchasica* (Kolakovsky & Shakryl) Ferguson is described by its macromorphology and micromorphology of the epidermis.

2) *Litsaeophyllum miocenicum* Juchniewicz described from the Lower Miocene of Turów Juchniewicz (1975) is revised on the basis of epidermal structure and assigned to *L. abchasica*.

3) The fossil record of *Laurus* and further Lauraceae leaves from Palaeogene and Neogene deposits of Poland is discussed. Most Lauraceae foliage are preserved as impressions only and their taxonomical position cannot be examined using cuticular analysis. Therefore, all lauraceous leaf taxa reported from the Tertiary of Poland based on macromorphology only should be considered as ambiguous. Only the *Daphnogene* morphotype and leaves examined by cuticular analysis can be considered as representatives of Lauraceae. In the Polish Neogene reliable records of Lauraceae foliage are not younger than Middle Miocene which is related to palaeogeogaphical and palaeoclimnatical conditions.

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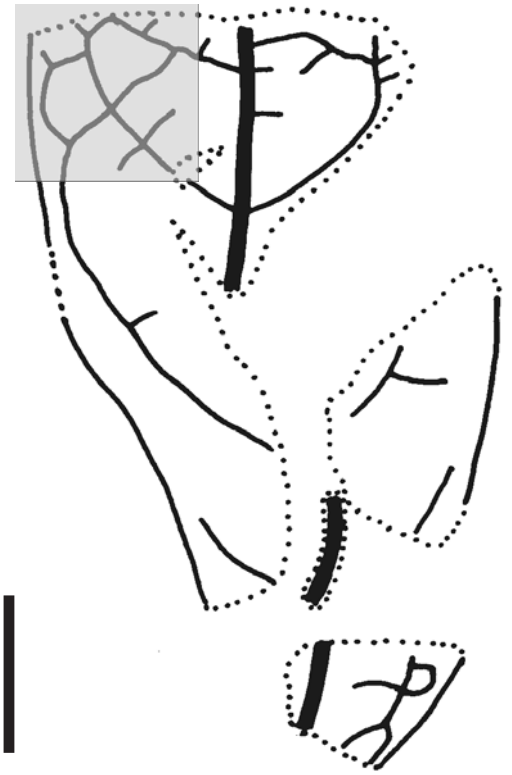
PLATES

Plate 1

Laurus abchasica (Kolakovsky & Shakryl) Ferguson

1. Line drawing of the leaf impression. Grey rectangle indicating the area from which isolated fragment of the leaf compression comes from, specimen No. KRAM-P 223/1
2. Isolated fragment of the leaf compression, specimen No. KRAM-P 223/1
3. Details of leaf venation, specimen No. KRAM-P 223/1
4. Details of leaf margin. Visible parallel ridge-like epidermal elevations on the leaf margin and fimbrial vein, specimen No. KRAM-P 223/1
5. Higher order venation network, with numerous idioblast secretory cells in the mesophyll, specimen No. KRAM-P 223/1
6. Details of the areole structure, with numerous idioblast secretory cells in the mesophyll, specimen No. KRAM-P 223/1

Scale bar: 1, 2 – 1 cm; 3 – 0.2 cm; 4, 5 – 0.1 cm; 6 – 100 μm



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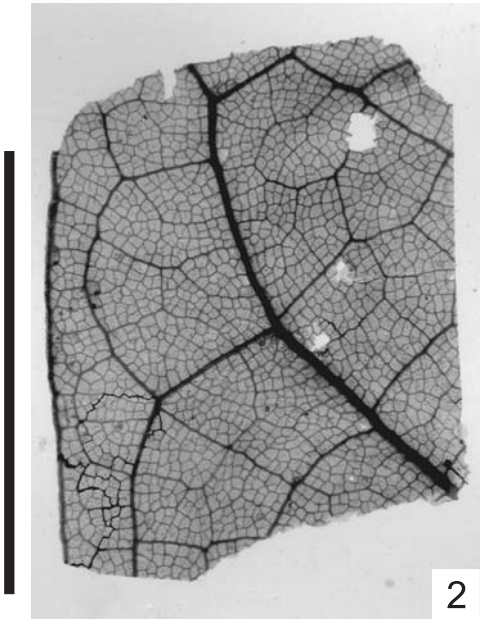

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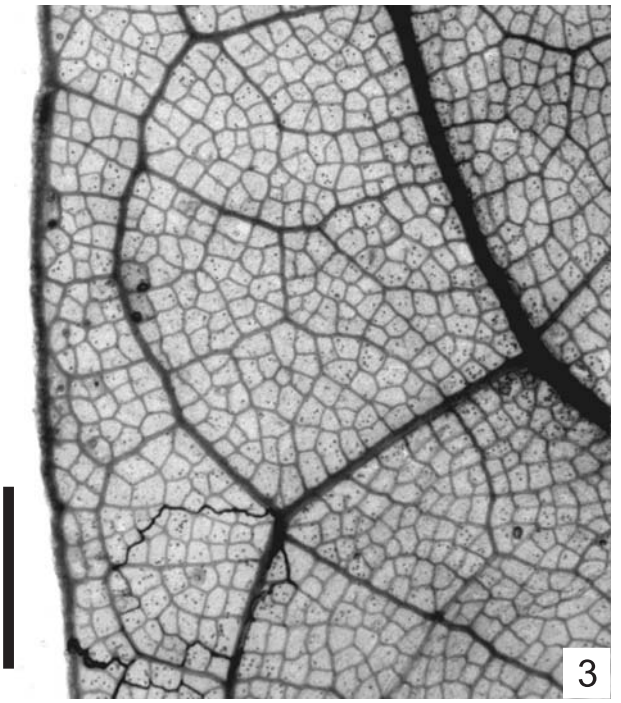

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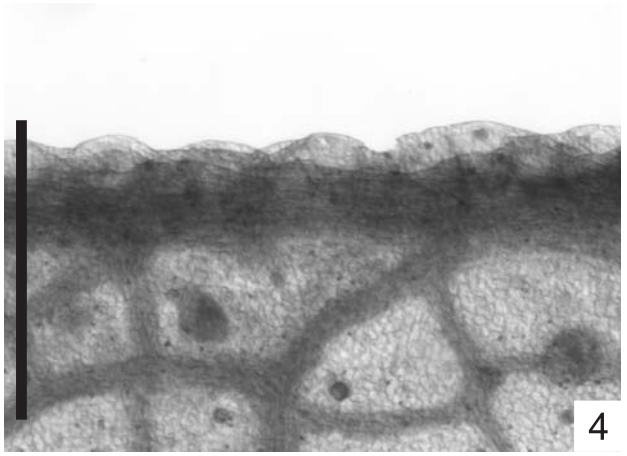

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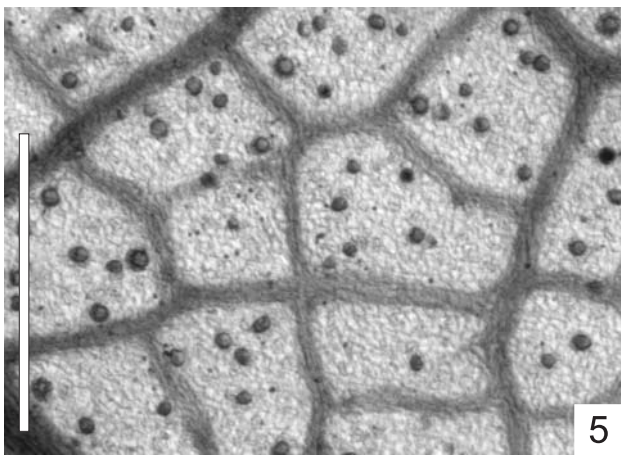

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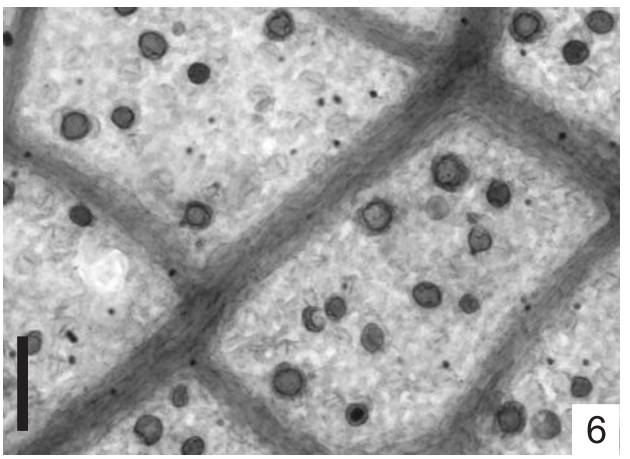

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Plate 2

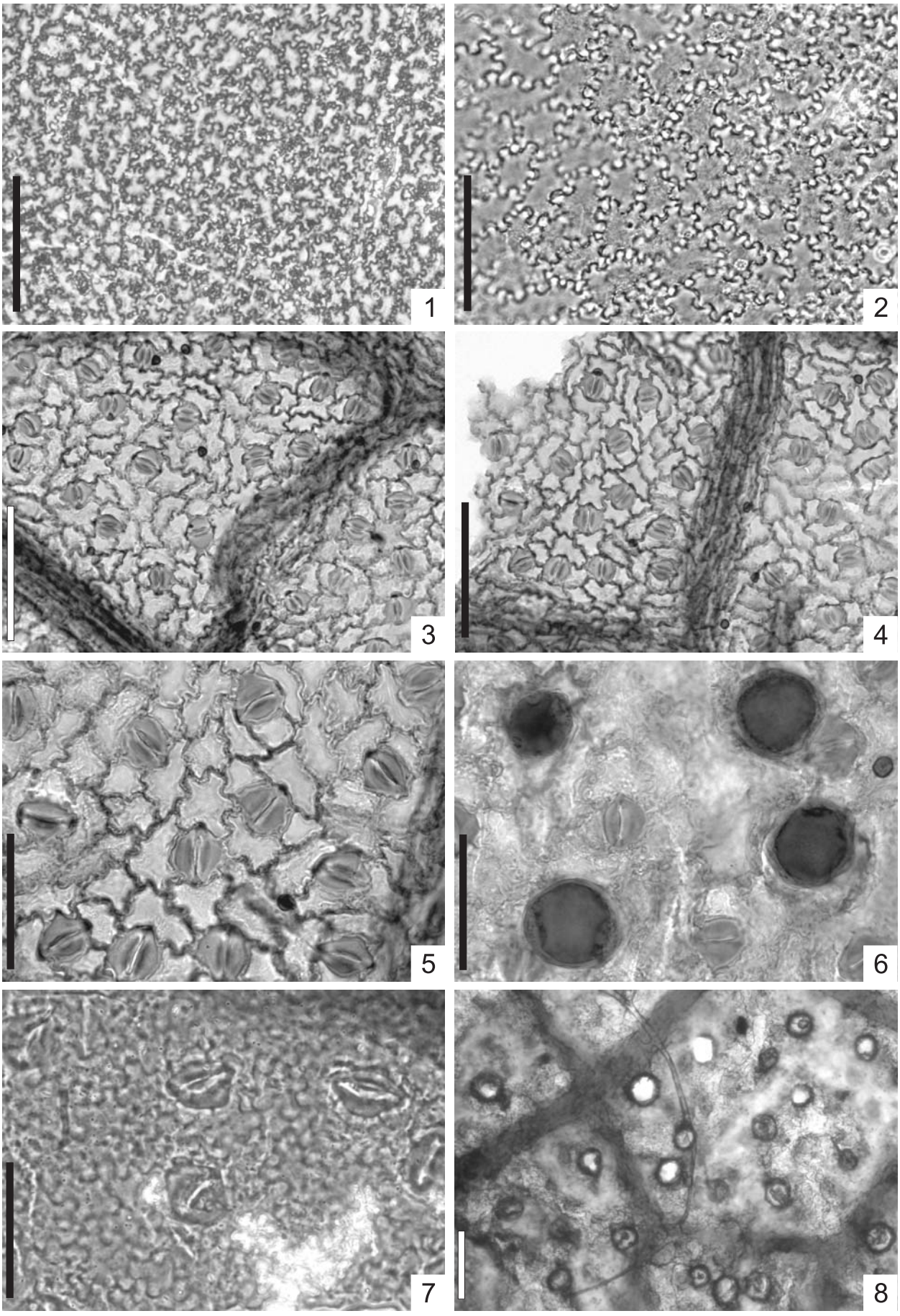
Laurus abchasica (Kolakovsky & Shakryl) Ferguson

1. Adaxial epidermis, specimen No. KRAM-P 223/1
2. Adaxial epidermis, specimen No. KRAM-P 223/1
3. Abaxial epidermis with stomata, specimen No. KRAM-P 223/1
4. Abaxial epidermis with stomata, specimen No. KRAM-P 223/1
5. Abaxial epidermis, visible rhomboidal stomata shape, specimen No. KRAM-P 223/1
6. Abaxial epidermis, details of idioblast secretory cell structure, specimen No. KRAM-P 223/1

Laurus abchasica (Kolakovsky & Shakryl) Ferguson
(formerly *Litsaeophyllum miocenicum* Juchniewicz)

7. Abaxial epidermis with rhomboidal stomata, and strongly undulate anticlinal cell walls. Lower Miocene, Turów mine (Lower Lusatia, Poland), Museum of the Earth, Polish Academy of Sciences, specimen No. 401
8. Idioblast secretory cells in the mesophyll. Lower Miocene, Turów mine (Lower Lusatia, Poland), Museum of the Earth, Polish Academy of Sciences, specimen No. 402 (Holotype of formerly *Litsaeophyllum miocenicum* Juchniewicz)

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