Acta Palaeobot. 34 (1): 83–105, 1994

UPPER MIOCENE FOSSIL PLANTS FROM THE OUTCROP OF STARE BYSTRE (WESTERN CARPATHIANS, POLAND)

Górnomioceńskie rośliny kopalne z odkrywki w Starym Bystrym (Zachodnie Karpaty)

GRZEGORZ WOROBIEC

W. Szafer Institute of Botany, Department of Palaeobotany, Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland

ABSTRACT. An outcrop on the Bystry Stream in the Orawa-Nowy Targ Basin shows a Neogene complex of sedimentary rocks (conglomerates, clays, sandy and sandy clayey deposits), in which an intercalation of pyroclastic deposits with plant remains was found. These deposits were dated by uranium-track method at 8.7 ± 0.6 million years BP. The fossil remains are preserved in the form of leaf and shoot impressions, representing 12 taxa of trees, shrubs and herbs, belonging to the genera *Acer, Alnus, Cornus, Cyperacites, Equisetum, Fagus, Pterocarya, Platanus, Populus, Salix* and *Zelkova.*

These are leaves impressions of deciduous trees growing in mesophilous forests of this area during the Upper Miocene (Pannonian-Pontian boundary).

KEY WORDS: Leaf flora, Orawa-Nowy Targ Basin, pyroclastic deposits, uranium-track method, Pannonian-Pontian boundary

INTRODUCTION

The site of the fossil flora at Stare Bystre (Fig. 1) is situated in the Oravian part of the Orawa-Nowy Targ Basin. The present-day floor of the basin lies between 580 and 800 m. a.s.l. It is covered by loamy-gravel freshwater deposits of the Neogene, with lignite horizons preserved in places. The Neogene deposits are overlain by Quaternary glaciofluvial sediments of the West-Tatran glaciers (Klimaszewski 1988).

The Neogene deposits in the Orawa-Nowy Targ Basin have been arousing great interest of geologists and palaeontologists for a long time now and the presence of lignites and fossil plant remains (fruits, seeds, leaves and sporomorphs) has induced them to undertake multidirectional studies and attempts to determine the age of the deposits more exactly (e.g. Foetterle 1851, Raciborski 1892, Halicki 1930, Szafer 1950, 1952, Urbaniak 1960, Łańcucka-Środoniowa 1965, Oszast & Stuchlik 1977, Birkenmajer 1954, 1958).

One of the most interesting exposures of the Neogene in Podhale is located in the

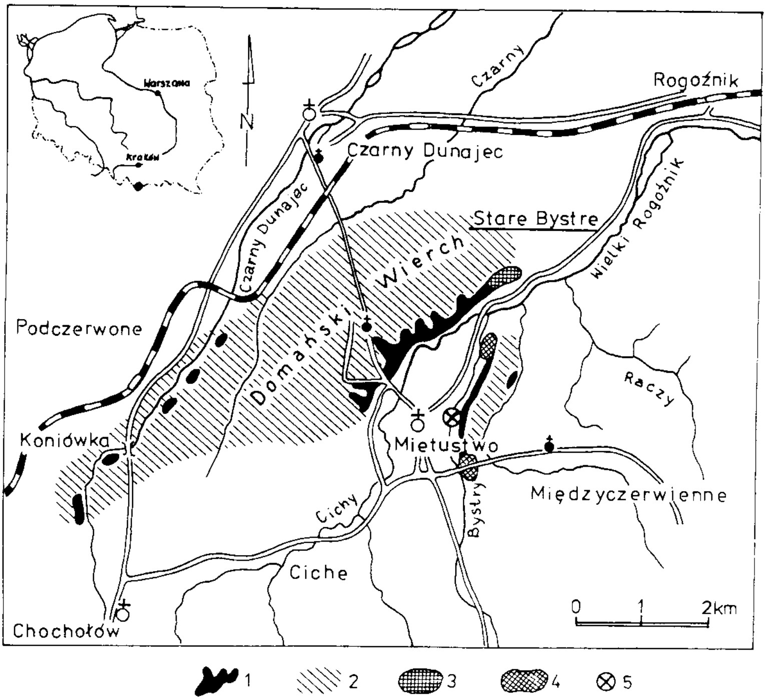


Fig. 1. Location sketch of Domański Wierch (after Birkenmajer 1958, somewhat amended). 1 – outcrops of Neogene; 2 – Neogene in shallow bedding; 3 – outcrop of the Branisko series at Stare Bystre; 4 – outcrop of the Podhale Flysch at the contact with the Neogene; 5 – locality of the outcrop with the leaf flora

region of the village of Stare Bystre*: it includes both a thick series of the alluvial cone of Domański Wierch (Birkenmajer 1954) and the underlying pyroclastic deposits of Stare Bystre (Sikora & Wieser 1974). Within the compass of the whole series there are both conglomerates and sandy-clayey materials, separated by a layer of tuffs and tuffits with well-preserved leaf impressions and with vegetal detritus (Sikora & Wieser op. cit.).

A DESCRIPTION OF THE SEDIMENTARY SERIES WITH A TUFF-TUFFIT COMPLEX

The exposure of deposits on the Bystry Stream near the village of Stare Bystre in conjunction with the borings at Domański Wierch made it possible to reconstruct a sedimentological series about 500 m in vertical thickness (Sikora & Wieser 1974).

At the bottom the Neogene formations, dipping to the north-west, contact directly with Podhale flysch. Conglomerates (c. 20 m thick) appear lowest and are overlain by

* The exposure is located nearer the village Miętustwo (comp. Sikora & Wieser 1974) but accepted name for the locality with radiomertric dated piroclastic deposits is Stare Bystre (Wieser 1985).

calcium-free clays and sands (c. 80 m), diagonally stratified in places. The next element is a layer of pyroclastic deposits. The tuff-tuffit horizon, which appears in the bank of the Bystry Stream is 1–2 m in thickness (Sikora & Wieser 1974). According to these authors, the tuffs and tuffits of Stare Bystre were deposited during the great volcanic eruptions of rhyolite phase III (Sarmatian) in nearby Slovakia, having a source in eruptions in the region of Kremickie Pohorze on the Horn.

A complex of heavily weathered conglomerates (c. 70 m thick) overlies the pyroclastic deposits and itself is, in turn, covered by strongly calcareous clays and sands c. 350 m thick. The thick series of the alluvial cone of Domański Wierch lies on those clays and sands as a stratigraphic cover.

The pyroclastic deposits from Stare Bystre were dated by Charles Naeser of the U.S. Geological Survey in Denver using the uranium-track method (Wieser 1985) at 8.7 ± 0.6 million years BP. In accordance with the chronology of the Neogene (Głazek & Szynkiewicz 1987) this places them in the uppermost part of the Upper Miocene and corresponds to the Pannonian-Pontian boundary. That age has therefore been assumed for the deposits with plant impressions.

MATERIAL AND METHODS

In the tuffs of Stare Bystre leaf remains were first found by Dr W. Sikora. The specimens described in the present paper were collected by W. Sikora, T. Wieser and E. Zastawniak in 1973 from the exposures of pyroclastic deposits in the region of the Bystry Stream. From among the samples taken for pollen analysis and examined by Assist. Prof. J. Oszast in 1973 (Oszast 1973b), only one from blue clays comprising vegetal detritus from the sub-tuffit complex of clays and sands, had a relatively well preserved pollen spectrum. This spectrum indicates the Neogene age of the deposits.

Leaves have been preserved in tuffits exclusively as impressions, devoid of any traces of vegetale tissues. The impressions are rarely present whole, more frequently as fragments of leaves, vegetale detritus is also visible. The colour of the specimens agrees most often with that of the rock (cream-grey); there are also some dark-brown specimens. The degree to which the venation of leaves is printed varies: there are some specimens in which the tertiary veins can be made out, but there are others in which only the main vein can be noticed and with difficulty at that.

The specimens from Stare Bystre are housed in the Palaeobotanical Museum of the W. Szafer Institute of Botany, Polish Academy of Sciences in Cracow (KRAM-P), Nos 136/1–32.

The drawings were made from under a Carl Zeiss stereoscopic microscope and a drawing apparatus. Each drawing is supplied with a scale of 1 cm.

The terminology followed in the descriptions is those proposed by Hickey (1973).

SYSTEMATIC PART

Pterophytina

Polypodiaceae gen. et sp. indet.

Pl. 3 fig. 5

M a t e r i a l. KRAM-P 136/28; 1 fragmentary leaf impression.

D e s c r i p t i o n. Fragmentary compound unpaired frond, 2 cm long and 1.2 cm wide. Fragments of 3–4 linear-lanceolate leaflets, broken off at ends, are disposed on both sides. The lower leaflets are 0.8 cm long and 0.3–0.4 cm wide; their measurements decrease towards the top. The margin of the top leaflet is entire, the leaflet is bent and its apex acute. Only the traces of the primary veins are preserved.

N o t e. The fragmentary leaf described above from its impression belongs most probably to the family *Polypodiaceae*, which supposition is supported by its shape and in particular by the shape of the top leaflet (cf. Ettingshausen 1865).

Remains of ferns from the family *Polypodiaceae* have been found from the Oligocene throughout the Pliocene deposits both in Europe (e.g. Kolakovskii 1964) and in Asia (e.g. Huzioka 1972) and North America (e.g. Graham 1965).

O c c u r r e n c e in the fossil floras of Poland. Leaf impressions of various taxa from the family *Polypodiaceae* are known from: Lower Miocene – Turów (Czeczott 1961, Juchniewicz 1975), Middle Miocene – Dobrzyń (Kownas 1956), Miocene – Zielona Góra and Chroślice (Kräusel 1920).

Sphaenophytina

Equisetaceae

Equisetum parlatorii (Heer) Schimper

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

1855. *Physagenia parlatorii* Heer, Heer p. 109, pl. 42, figs 2–17
1870–1872. *Equisetum parlatorii* (Heer) Schimper, Shimper p. 261

M a t e r i a l. KRAM-P 136/1; fragment of a rhizome with root tubers.

D e s c r i p t i o n. A fragment of a rhizome with root tubers. It is a segment, 3.4 cm long and 0.4 cm in diameter, marked with distinct parallel grooves; three spindle-shaped tubers, measuring 1.9 x 0.4–0.5 cm, go off from the rhizome at the internode. They are radialy arranged and at the top of one of them a fourth tuber is visible, placed linearly. A short fragment of a horsetail stem or rhizome occurs beside the rhizome with tubers.

N o t e. The parallel grooves distinctly seen on the rhizome, the presence of the internode and the characteristically arranged root tubers point at the genus *Equisetum*. The position of the rhizome and tubers in the deposit suggests their occurrence in situ.

Fossil remains of horsetails are known from the Neogene of Europe as *Equisetum parlatorii* (Heer) Schimper (e.g. Unger 1860, Andreánszky 1959, Ilinskaya 1968, Zastawniak 1972, Shvareva 1983, Kovar-Eder & Krainer 1990).

O c c u r r e n c e in the fossil floras of Poland. Pliocene – Domański Wierch (Zastawniak 1972).

Angiospermae – Dicotyledones

Betulaceae

Alnus cecropiaefolia (Ett.) Berger

Pl. 2 figs 2, 2a, Fig. 2: 9

1851. *Artocarpidium cecropiaefolium* Ett., Ettingshausen p. 15, pl. 2, figs 3–4
1955 *Alnus cecropiaefolia* (Ett.) Berger, Berger p. 87, textfig. 30

M a t e r i a l. KRAM-P 136/5; 1 leaf impression.
D e s c r i p t i o n. Leaf round, 6.3 cm long and 5.9 cm wide. Apex probably acute, leaf base damaged. A small fragment of the petiole is visible. Leaf margin dentate, teeth fine, 1 mm high and 1–1.5 mm across at base, margins of teeth straight or somewhat convex. The partly damaged midrib seems to be curved. The lateral veins, numbering 11 pairs, alternately arranged, do not differ much in thickness from the midrib. The average distance between them is constant: 0.6 cm. Only at the leaf-base they run close to each other at an interval of 1 mm. The angle formed by the midrib and lateral vein is 40–45°.

Venation simple craspedodromous. The lateral veins are uniformly curved upwards over their whole length, the degree of curvature increasing from the leaf-base towards the top. The lateral veins, especially the lowest ones, give off 1–4 branches. The venation of tertiary order is very distinct, of the percurrent type; straight, oblique veins run at an average distance of 1 mm (10–12 tertiary-order veins per one-centimetre length of the lateral vein). They form an angle of about 110° with the midrib. Close to the leaf margin the tertiaries give off short branchlets which end in the teeth.
N o t e. The shape of the leaf and the features of its venation allow to include of the leaf impression under study in the species *Alnus cecropiaefolia* (Ett.) Berger, known from the Upper Miocene and Pliocene of Europe (Berger 1955, Knobloch 1969 etc.). This species is comparable to the modern Central American species *Alnus priglei* Fern. (Knobloch 1969). The Asiatic species *Alnus barbata* C. A. Mey. also has leaves similar in shape.
O c c u r r e n c e in the fossil floras of Poland. Middle Miocene – Chodzież (= *Alnus kefersteinii* Goepp., Zabłocki 1924), Stare Gliwice, Stawiany (Zastawniak 1980). Upper Miocene – Bełchatów (Stuchlik et al. 1990). Miocene – Stara Jamka (Zastawniak 1980). Pliocene – Domański Wierch (Zastawniak 1972).

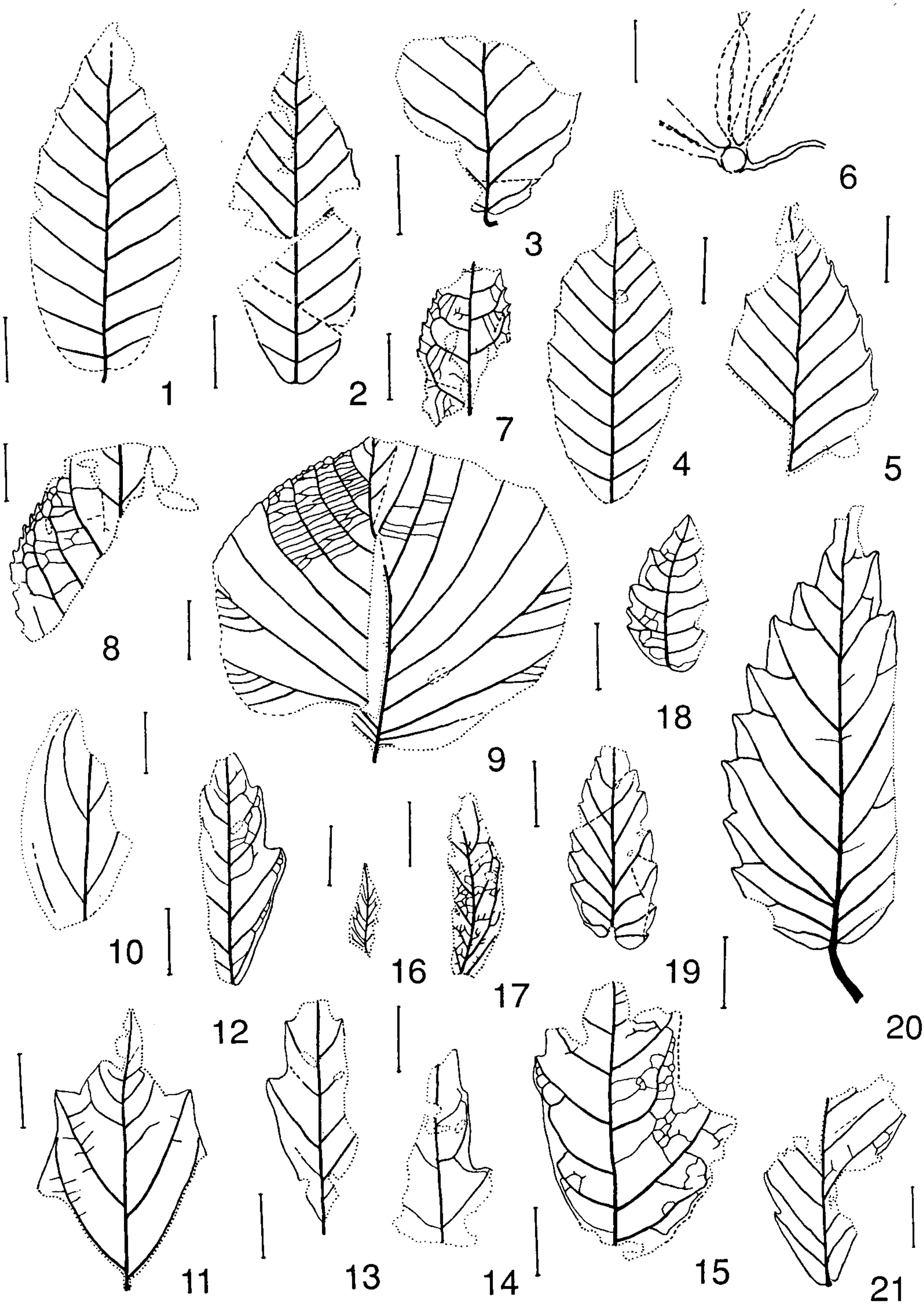
Fagaceae

Fagus haidingeri Kováts sensu Knobloch

Pl. 1 figs 1–3, Fig. 2: 1–5

1856. *Fagus haidingeri* Kov., Kováts p. 24, pl. 4, figs 6,7
1969. *Fagus haidingeri* Kováts sensu Knobloch, Knobloch fig. 184; pl. 36, figs 2–8, 10–11; pl. 37, figs 1–11; pl. 38, figs 2–11
1980. *Fagus orientalis* Lipsky foss. Palibin, Zastawniak fig. 5: 5–10; pl. 1, fig. 8

M a t e r i a l. KRAM-P 136/2, 9, 11, 13/I,II, 19, 23, 25, 26, 27; 9 impressions of whole leaves and fragments.
D e s c r i p t i o n. Leaves elliptic or elliptic-ovate in shape, symmetrical, with acute apex and cuneate base. The specimens are 4.7–5 cm long and 1.8–2.2 cm wide. The leaf margins are serrate, the teeth being slightly bent upwards, about 0.1 cm height and 0.1–0.2 cm wide at the base. The upper margins of the teeth are generally concave, the lower ones straight or somewhat convex. Leaf venation pseudocraspedodromous; midrib straight, of medium thickness. Lateral veins straight, 8–10 pairs in number, close to the very margin of the leaf-blade slightly curved upwards; they arise from the midrib at an angle of 40–55° (70° at the base). The lateral veins do not reach the leaf margin.
N o t e. The leaf remains are characteristic of the genus *Fagus*. They have been included in the species *Fagus haidingeri* Kov. sensu Knobloch for their elliptic-ovate shape,


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

acute apex and the typical position of teeth. The specimens described most resemble the leaves of *Fagus haidingeri* Kováts from the Pannonian of Moravia (Knobloch 1969) and *Fagus orientalis* Lipsky foss. Palibin from the Sarmatian of Holy Cross Mts. (Zastawniak 1980).

There are, besides, four leaf fragments (Fig. 2: 3) varying in size, with characteristic venation. Probably, they belong to the same beech species.

Occurrence in the fossil floras of Poland. Middle Miocene – Młyny (Zastawniak 1972), Upper Miocene – Bełchatów (= *Fagus silesiaca*, Walther et Zastawniak 1991), Pliocene – Domański Wierch (Zastawniak 1972).

Juglandaceae

Pterocarya paradisiaca (Ung.) Ilinskaya

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

1849. *Prunus paradisiaca* Ung., Unger p. 7, pl. 14, fig. 22
1962. *Pterocarya paradisiaca* (Ung.) Ilinskaya, Ilinskaya p. 104

Material. KRAM-P 136/6; 1 impression of a leaflet fragment.

Description. A part of an oblong leaflet, without the apex, 2.6 cm long and 1.5 cm wide. Leaflet margin serrate, teeth 0.5–1 mm high and about 2 mm wide at base; their upper and lower margins are straight. On the average there are 5 teeth per 1 cm of the blade margin.

Venation semicraspedodromous. The midrib is straight, of medium thickness. The lateral veins distinctly thinner than the midrib, arise from it alternately at angles of 60–70°. They are curved upwards, at first weakly and regularly; by the margin of leaf the endings of these veins form together characteristic broad loops, which give off branches to the teeth. The intersecondary veins are present, short and not very distinct. The tertiary veins straight or slightly curved, run 1 mm apart (weakly percurrent). The angle between the midrib and tertiaries is about 150°.

Note. On the basis of the characteristic venation of second and third order and shape of the leaflet margins the specimen under study has been placed in the genus *Pterocarya*. The leaflets of this genus differ from the leaflets of *Carya* in their semicraspedodromous venation. The only fossil leaves species of this genus, *Pterocarya paradisiaca* (Ung.) Ilinskaya, occurs commonly from the Oligocene to the Pliocene at many localities all over Europe (Ilinskaya 1962, 1964, Knobloch 1969, Knobloch & Velitzelos 1987, Palamarev & Petkova 1987).

The determination of *Pterocarya castaneifolia* (Goepp.) Schlecht. from Turów

←

Fig. 2. 1–5 – *Fagus haidingeri* Kováts sensu Knobloch: 1 – specimen KRAM-P 136/2, 2 – specimen KRAM-P 136/25 & 136/26, 3 – specimen KRAM-P 136/11, 4 – specimen KRAM-P 136/9, 5 – specimen KRAM-P 136/13; 6 – *Equisetum parlatorii* (Heer) Schimper – specimen KRAM-P 136/1; 7 – *Pterocarya paradisiaca* (Ung.) Ilinskaya – specimen KRAM-P 136/6; 8 – *Populus* sp. – specimen KRAM-P 136/7; 9 – *Alnus cecropiaefolia* (Ett.) Berger – specimen KRAM-P 136/5; 10 – *Cornus* sp. – specimen KRAM-P 136/17; 11 – *Platanus leucophylla* (Ung.) Knobloch – specimen KRAM-P 136/3; 12–15 – *Acer quercifolium* (Goepp.) Kovar-Eder: 12 – specimen KRAM-P 136/9b, 13 – specimen KRAM-P 136/9a, 14 – specimen KRAM-P 136/16, 15 – specimen KRAM-P 136/3; 16–17 – *Salix* sp. div.: 16 – specimen KRAM-P 136/14, 17 – specimen KRAM-P 136/12a; 18–21 – *Zelkova zelkovaefolia* (Ung.) Bůžek et Kotlaba: 18 – specimen KRAM-P 136/4, 19 – specimen KRAM-P 136/8, 20 – specimen KRAM-P 136/28, 21 – specimen KRAM-P 136/29. Scale 1 cm

(Czeczott & Skirgiełło 1961) is questionable. The venation of the leaf from Osieczów, described under the same name by Raniecka-Bobrowska (1962) does not correspond with the leaflets of the genus *Pterocarya*.
Occurrence in the fossil floras of Poland. Middle Miocene – Młyny (Zastawniak 1980), Upper Miocene – Bełchatów (Stuchlik et all. 1990), Pliocene – Domański Wierch (Zastawniak 1972).

Salicaceae

Salix sp. div.

Pl. 1 fig. 5, Fig. 2: 16, 17

Material. KRAM-P 136/12a i 12b, 14; 2 fragmentary leaf impressions. One with twin impressions.
Description. Leaves narrow oblong in shape, probably with a cuneate base and attenuate apex, 0.8 cm wide. The margins of both leaves are damaged. Venation camptodromous, midrib of medium thickness. The lateral veins go off the midrib alternately at intervals of 0.3–0.8 cm, they curve upwards at an angle of 30–50°, which increases towards the leaf apex. The veins of third order are random reticulate.
Note. The lanceolate shape of the leaf and the arrangement of the lateral veins indicate the genus *Salix*. The state of preservation does not allow the exact specific determination of the specimens under discussion.
Occurrence in the fossil floras of Poland. *Salix* is common in the Neogene fossil floras of Poland.

Populus sp.

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

Material. KRAM-P 136/7; 1 impression of fragmentary leaf.
Description. A leaf fragment with characteristically serrate margins has been preserved. Teeth 0.1 cm high and 0.2 cm wide at base, rounded at top; upper margins of teeth concave, the lower ones convex. On the average 5 teeth fall to 1 cm of the blade margin.

Venation camptodromous. A short fragment of midrib is preserved. The lateral veins are connected by polygonal loops, which give off branches entering the teeth and ending at their tips or at the boundary between two teeth. The tertiaries are lightly bent and they link the lateral veins at intervals of 0.2–0.3 cm. They are weakly percurrent and oblique.
Note. The characteristically shaped margin of the leaf and the features of the second-order venation permit the identification of the fragment as a part of a leaf of *Populus*.
Occurrence in fossil floras of Poland. *Populus* is common in the Neogene fossil floras of Poland.

Ulmaceae

Zelkova zelkovaefolia (Ung.) Bůžek et Kotlaba

Pl. 1 fig. 4, Pl. 3 figs 3–4, Fig. 2: 18–21

1841. *Ulmus zelkovaefolia* Ung., Unger p. 94, pl. 24, figs 9–12; tabl. 26, fig. 7
1963. *Zelkova zelkovaefolia* (Ung.) Bůžek et Kotlaba, Kotlaba p. 59, pl. 3, figs 7, 8

Material. KRAM-P 136/4, 8, 28, 29, 30; 4 impressions of whole and fragmentary leaves, one with twin impressions.
Description. Leaves 2.5–6.3 cm in length and 1.2–2.5 cm in width, elliptic-ovate, with an acute apex and an asymmetrical cordate base. Petiole 0.9 cm long. Leaf margins simple serrate, teeth 0.1–0.3(0.4) cm high and max. 0.8 cm wide at base. Upper and lower margins of teeth acuminate.

Venation simple craspedodromous. Midrib generally straight and relatively thick. Lateral veins of medium thickness, 8–11 pairs in number, attached alternately to the midrib, 0.2–1 cm apart, at an angle of 40–50° in the middle part of the leaf. Intersecondary veins rare. Tertiaries poorly seen, probably orthogonal reticulate/weak percurrent, the angle of the tertiaries with the midrib approximates 135°.
Note. The specimens described have venation and serrate margins characteristic of the genus *Zelkova*. They have been included in the species *Zelkova zelkovaefolia* (Ung.) Bůžek et Kotlaba. The leaves known as *Zelkova praelonga* (Ung.) Berger belong probably to the species *Zelkova zelkovaefolia* (Ung.) Bůžek et Kotlaba, for the only difference between them – in the shape of the apex (acuminate in *Zelkova praelonga* (Ung.) Berger) – seems to be too low a rank if we take into consideration the environmental variation of tree leaves.
Occurrence in the fossil floras of Poland. Middle Miocene – Młyny (Zastawniak 1980), Upper Miocene – Bełchatów (Stuchlik et al. 1990), Pliocene – Domański Wierch (Zastawniak 1972). The other localities see Zastawniak (1972).

Platanaceae

Platanus leucophylla (Ung.) Knobloch

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

1850. *Populus leucophylla* Unger, Unger p. 417
1971. *Platanus leucophylla* (Ung.) Knobloch, Knobloch p. 264

Material. KRAM-P 136/3; impression of leaf fragment.
Description. The extant fragment, 3.8 cm long and 2.1 cm wide, is a leaflet, probably the middle one of a leaf. The apex is acuminate. The leaflet margin shows two teeth, 0.3 cm in height and 0.4 cm in width at the base. The upper margins of the teeth are straight, the lower ones convex. The lateral veins leave the midrib of the leaflet at 40–45°, 0.3–1.2 cm apart; Their distinctly increased density is visible near the top of the leaflet. The veins of third order, straight or curved, form distinct transverse anastomoses between the veins of second order. The percurrent tertiary veins divide the leaflet blade into numerous elongate, regular rectangles.
Note. The leaflet fragment preserved appeared sufficiently characteristic to be referred to the species *Platanus leucophylla* (Ung.) Knobloch.
Occurrence in the fossil floras of Poland. Middle Miocene – Stawiany (Zastawniak 1980), Upper Miocene – Bełchatów (Stuchlik et al. 1990). The other localities see Zastawniak (1972). The leaves of *Platanus platanifolia* (Ett.) Knobloch from the Pliocene of Domański Wierch do not belong to this genus (Zastawniak, oral information).

Cornaceae

Cornus sp.

Pl. 3 fig. 2, Fig. 2: 10

Material. KRAM-P 136/17; 1 leaf impression.

Description. Leaf fragment, 3.8 cm long and 2.1 cm wide. The shape of the leaf probably elliptic, venation eucamptodromous. Midrib straight, thick, lateral veins diverging from it at about 40° and at intervals of 1.5 cm. They are strongly arcuately bent, uniformly over their whole length.

Note. The specimen described has been acknowledged to be an impression of a leaf of *Cornus* on the basis of its characteristic eucamptodromous venation and the arrangement of the lateral veins. A leaf impression of similar morphological traits was found in the flora of Domański Wierch and described as *Cornus* cf. *mas* L. (Zastawniak 1972). The leaves of cornels are infrequently found in fossil floras of the Tertiary of Europe (Palamarev 1964, Andreánszky 1959). The leaves described as *Cornus büchii* Heer from Dobrzyń (Kownas 1956) call for verification.

Occurrence in the fossil floras of Poland. Pliocene – Domański Wierch (Zastawniak 1972).

Aceraceae

Acer quercifolium (Goepp.) Kovar-Eder

Pl. 3 fig. 6, Fig. 2: 12–15

1855. *Rhus quercifolia* Goepp., Goeppert p. 37, pl. 25, figs 6–9
1855. *Rhus aegopodifolia* Goepp., Goeppert p. 37, pl. 25, fig. 10
1959. *Monopleurophyllum hungaricum* Andreánszky, Andreánszky p. 168, fig. 201, pl. 48, fig. 6, pl. 50, fig. 2, pl. 52, fig. 7, pl. 53, figs 3, 4, pl. 65, fig. 2, pl. 66, fig. 3
1963. *Monopleurophyllum quercifolium* (Goepp.) Kotlaba, Kotlaba p. 63, pl. 5, figs 4, 5
1965. *Acer aegopodifolium* (Goepp.) Baikovskaya, Shvareva p. 953
1988. *Acer quercifolium* (Goepp.) comb. nov., Kovar-Eder p. 51, pl. 6, figs 14–16

Material. KRAM-P 136/3, 9 i 9b, 16; 3 impressions of fragmentary leaves, one with twin impressions.

Description. Impressions of fragmentary leaflets of compound leaves, 3.7–4.1 cm long and 1.2–2.7 cm wide. One of the leaflets is distinctly asymmetrical. Leaflet base cuneate or lightly rounded. Petiole short, 0.2 cm. Large teeth, 0.1–0.3 cm high and 0.4–0.6 cm wide at base are present on the leaf margin. Venation imperfect actinodromous. The main vein, rather thick, ramifies above the base. The lateral veins diverge alternately from the primary vein at an angle of 40–60°, 0.3–0.7 cm apart. The lateral veins curve upwards approximately uniformly over their whole length and their endings enter the leaflets, reaching the margin of the leaflet blade. The intersecondary veins are not numerous and generally short. A random reticulate pattern characterisies the network of tertiary veins and the venation of higher orders is relatively random.

Note. The specimens are parts of compound leaves of the fossil species *Acer quercifolium* (Goepp.) Kovar-Eder, which is suggested by the venation pattern and characteristic on the leaf teeth's. Remains of this type, known also under the names of *Monopleurophyllum quercifolium* (Goepp.) Kotlaba, *Monopleurophyllum hungaricum* Andreánszky, *Rhus quercifolium* Goepp. and *Acer aegopodifolium* (Goepp.) Baikovskaya, most resemble the present-day species *Acer griseum* (Franch.) Pax, growing in Central China (Ilinskaya 1968).

It should be mentioned, that the Cretaceous floras of Alaska, Sakhalin and Siberia contain leaf taxon named *Acer quercifolium* (Hollick) Baikovskaya (Takhtajan et al. 1963) (= *Rulac quercifolium* Hollick, (Hollick 1930). However, this name in this case is invalid (comp. Greuter 1988, art. 64).

Occurrence in the fossil floras of Poland. Middle Miocene – Młyny (= *Monopleurophyllum quercifolium* (Goepp.) Kotlaba; Zastawniak 1980); Upper Miocene – Sośnica (= *Rhus quercifolia* Goepp., *R. aegopodifolia* Goepp.; Goeppert 1855), Bełchatów (= *Monopleurophyllum quercifolium* (Goepp.) Kotlaba; Stuchlik et al. (1990).

Dicotyledones incertae sedis

? *Salix*

Fig. 3: 1, 3

Material. KRAM-P 136/13, 15; 2 impression of leaf fragments.

Description. Small fragments of leaves with camptodromous venation. Lateral veins approximately uniformly bent towards the top, arise oppositely from the primary vein at angles of 60–70^{o}; their ends join together, forming loops.

Note. The shape of leaves and the character of venation probably indicate the genus *Salix*.

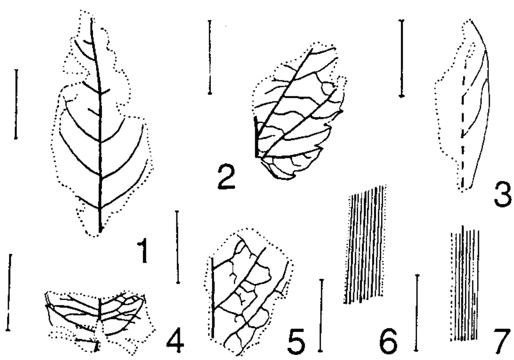


Fig. 3. 1, 3 – ? *Salix*: 1 – specimen KRAM-P 136/13a, 3 –specimen KRAM-P 136/15; 2 – *Ribes* vel *Rubus* – specimen KRAM-P136/13b; 4–5 – Dicotyledones gen. et sp. indet.: 4 – specimen KRAM-P 136/31, 5 – specimen KRAM-P 136/18; 6 – *Cyperacites* sp. div. – specimen KRAM-P 136/32; 7 – Monocotyledones gen. et sp. indet. – specimen KRAM-P 136/31. Scale 1 cm

Ribes vel *Rubus*

Fig. 3: 2

Material. KRAM-P 136/13; 1 impression of leaf fragment.

Description. A small fragment of the base of a leaf blade has survived; it is 2 cm long and 1.3 cm wide. Base margin serrate, marginal teeth varying in size, 0.1 cm high and 0.15–0.2 cm across at base, bent upwards. Fragments of the tertiary veins are visible, their arrangement being conformable to the percurrent retroflexed type.

Note. The shape of the base, the serrate leaf margin and third order veins resembles those in the leaves of the contemporary genera *Ribes* and *Rubus*.

Dicotyledones gen. et sp. indet.
Fig. 3: 4–5

Material. KRAM-P 136/9, 18, 20, 21, 22, 23, 25, 31; several impressions of leaf fragments.
Note. Small leaf fragments with the preserved venation typical of dicotyledonous plants, not allowing a closer determination.

Angiospermae – Monocotyledones

Cyperaceae
Cyperacites sp. div.
Fig. 3: 6

Material. KRAM-P 136/32; 4 impressions of fragmentary leaves.
Description. Fragments of linear leaves of monocotyledonous plants, 2–2.5 cm long and 0.25–0.6 cm wide. Venation parallelodromous, veins extend 0.2–0.4 cm apart. The specimens show a characteristic bend of the leaves in the shape of the letter M.
Note. The features of these specimens are characteristic of the leaves of *Cyperacites* (cf. Zastawniak 1972, fig. 4d).

Monocotyledones gen. et sp. indet.
Fig. 3: 7

Material. KRAM-P 136/31; 1 leaf fragment.
Description. A fragment of a linear leaf with parallelodromous venation.

GENERAL CHARACTERISTICS OF MATERIAL

In the material under study 41 specimens have been determined and assigned to 11 genera and 11 families of vascular plants. Several poorly preserved small fragments of leaves have a questionable systematic position. With the exception of two genera all the remaining ones belong to angiosperous plants. The lack of macrofossils of gymnosperms is probably accidental here, because in a palynological sample taken from the adjoining layers of neighbouring site of Domański Wierch (Oszast 1973a) they are represented by rather numerous pollen grains of various conifers (*Abies, Glyptostrobus, Picea, Pinus, Sequoia, Tsuga, Taxodiaceae-Cupressaceae*). It may well be that coniferous forest grew somewhat farther from the place of sedimentation, while beechwood may have surrounded it directly, which is suggested by the most abundant remains of the fossil leaves of *Fagus haidingeri* Kov. sensu Knobloch in the whole taphocoenosis.

Another type of woodland occurring in this area is perhaps riverside carr covering the banks of the stream and its flood plains, with *Alnus cecropiaefolia* (Ett.) Berger, *Pterocarya paradisiaca* (Ung.) Ilinskaya, *Populus* sp., *Zelkova zelkovaefolia* (Ung.) Bůžek et Kotlaba, *Platanus leucophylla* (Ung.) Knobloch and *Acer quercifolium* (Goepp.) Kovar-Eder. Shrubs of *Cornus* and *Ribes/Rubus* grew in the undergrowth of that forest, whereas horsetails and ferns from the family *Polypodiaceae* were present in wetter places. The occurrence of horsetail in this material is particularly interesting; its disposition in sediments indicates that it certainly grew in situ.

AGE OF PLANT REMAINS FROM STARE BYSTRE AND THEIR COMPARISON WITH THE FLORA OF DOMAŃSKI WIERCH RISING IN ITS CLOSE VICINITY

The date of 8.7 ± 0.6 million years BP., obtained by the track method for the deposits with leaf impressions at Stare Bystre (Wieser 1985) unambiguously determines the age of the plant remains found there. It points at the Pannonian/Pontian boundary, according to the chronostratigraphic division accepted for the Upper Tertiary and Lower Quaternary karst deposits in Poland by Głazek and Szynkiewicz (1987). In the stratigraphic table published by Gregor, Knobloch, Schölz and Unger (1992) in the space of the Central Paratethys this date lies in the upper part of the Pannonian. Irrespective of the differences between the opinions on the stratigraphic range of particular stages of the Central Paratethys, the plant remains from Stare Bystre undoubtedly represent the vegetation of the uppermost part of the Upper Miocene. It is besides the one of the few localities of the Neogene flora in Poland with its age so accurately and explicitly determined.

The date of 8.7 ± 0.6 million years BP. obtained for the remains from Stare Bystre indirectly confirms the younger age of the overlying series of deposits of the alluvial cone of Domański Wierch, determined on the basis of palynological studies (Oszast 1970, 1973a) and the leaf flora (Zastawniak 1972). A comparison of the taxonomic composition of the taphocoenoses from Stare Bystre and Domański Wierch by itself provides no data as to the stratigraphic position in relation to each other. All the plant genera found at Stare Bystre were also identified in the flora of Domański Wierch, whereas many genera occurring in the flora of Domański Wierch are lacking at Stare Bystre; no conclusion can be drawn from this fact at that, if we keep in mind the numbers of specimens in the two taphocoenoses being compared (41 specimens from Stare Bystre (Tab. 1) and 389 specimens of the flora from Domański Wierch (Zastawniak 1972, Tab. 3).

Despite the considerably poorer representation of plant taxa in the flora of Stare Bystre in both floras under comparison the same types of plant communities found their reflection, that is, beech wood and riverside carr with plants of wood undergrowth. In both taphocoenoses macrofossils of coniferous plants are lacking.

Both above-mentioned types of woodland communities played an important role in the plant cover of the Neogene of the Orawa-Nowy Targ Basin, which has already been proved on the basis of palynological studies before (Oszast & Stuchlik 1977). In the Upper Miocene woods with a high proportion of *Alnus, Platanus, Populus, Pterocarya, Salix* and *Liquidambar* occupied flat or slightly wavy areas on mineral soils with a high ground-water table. On the other hand, on the slopes surrounding the Basin, woodland communities developed at that time, with dominant *Fagaceae, Juglandaceae, Magnoliaceae* with the genera *Carpinus* and *Tilia*. Birches, pines and hemlocks also grew in them

Table 1. Plant remains found in outcrop near Stare Bystre

Name of taxon	Number of remains
Polypodiaceae	
Polypodiaceae gen. indet.	1
Equisetaceae	
Equisetum parlatorii (Heer) Schimper	1
Betulaceae	
Alnus cecropiaefolia (Ett.) Berger	1
Fagaceae	
Fagus haidingeri Kov. sensu Knobloch	9
Juglandaceae	
Pterocarya paradisiaca (Ung.) Ilinskaya	1
Salicaceae	
Salix sp. div.	2
Populus sp.	1
Ulmaceae	
Zelkova zelkovaefolia (Ung.) Bůžek et Kotlaba	4
Platanaceae	
Platanus leucophylla (Ung.) Knobloch	1
Cornaceae	
Cornus sp.	1
Aceraceae	
Acer quercifolium (Goepp.) Kovar-Eder	3
Dicotyledones incertae sedis	
? *Salix*	2
Ribes vel *Rubus*	1
Dicotyledones gen. et sp. indet.	8
Cyperaceae	
Cyperacites sp. div.	4
Monocotyledones gen. et sp. indet.	1
Total	41

and in places were accompanied by more thermophilous woods and thickets with a high proportion of oak (Oszast & Stuchlik op. cit.). In wet places and on fertile soils *Parrotia* grew in the undergrowth of forests; it is very abundantly represented in flora of Domański Wierch.

PRESENT-DAY EQUIVALENTS OF THE TAPHOCOENOSIS OF STARE BYSTRE

In search of the present-day equivalents for the Upper Miocene fossil flora of Stare Bystre, special attention was given to the here found genera *Zelkova, Pterocarya* and *Platanus*. Nowadays they occur in the warmer regions of Europe, Asia and North

America. Their presence, especially of *Zelkova* and *Pterocarya*, and the occurrence of such genera as *Alnus* or *Fagus* indicate that the Upper Miocene woodland covering the slopes of the present Orava-Nowy Targ Basin may have been then similar to the modern forest of the moderately warm zone occurring on the southern slopes of the Caucasus and in the Talysh Lowland and in the Colchis Lowland. The characteristic features of the plant cover of these regions have been presented by Podbielkowski (1987). However, because of a small number of taxa found at Stare Bystre, the determination of the close affinity of the woodland of Stare Bystre in the Upper Miocene with the corresponding types of the present-day forest communities is not possible and the foregoing inference is only to a certain degree probable.

ACKNOWLEDGEMENTS

I wish to express my heartfelt thanks to Assist. Prof. Ewa Zastawniak, who was my guide into the difficult field of studies on macroscopic floras of the Cenozoic. I extend my thanks to her not only for the study material and help with identification of specimens but also for her valuable advice.

My thanks go to Assist. Prof. K. Poprawa, Head of the Carpathian Division of the State Institute of Geology for help me to carry out quest of additional materials in the village of Stare Bystre in June 1993 and to Dr A. Wójcik and Mr J. Wieser for keeping me company in field expedition.

Prof. dr L. Stuchlik very thanks for a critical drafting of text. Ms Z. Tomczyńska and Mr J. Wieser helped me with drawing situational sketches and Mr A. Pachoński took photographs for which I thank all the persons mentioned very much.

REFERENCES

ANDREÁNSZKY G. 1959. Die Flora sarmatischen Stufe in Ungarn. Akademiai Kiado. Budapest.

BERGER W. 1955. Die altpliozäne Flora des Laaerberges in Wien. Palaeontogr. B, 97 (3–6): 81–113.

BIRKENMAJER K. 1954. Sprawozdanie z badań geologicznych wykonanych w Tatrach, w Pieninach i na Podhalu (summary: Geological investigations of Podhale neogene, Central Carpathians). Biul. Inst. Geol., 86: 59–79.

— 1958. Przewodnik geologiczny po Pienińskim Pasie Skałkowym. Cz. 1 i 2. Wyd. Geol. Warszawa.

CZECZOTT H. 1961. *Filicinae*. In: Czeczott H. (ed.) Flora kopalna Turowa koło Bogatyni (summary: The fossil flora of Turów near Bogatynia). Pr. Muz. Ziemi, 4: 3–117.

— & SKIRGIEŁŁO A. 1961. *Juglandaceae*. In: Czeczott H. (ed.) Flora kopalna Turowa koło Bogatyni (summary: The fossil flora of Turów near Bogatynia). Pr. Muz. Ziemi, 4: 3–117.

ETTINGSHAUSEN C. 1851. Der Tertiäre-Floren der Oesterreichischen Monarchie 1. Abh. Geol. Reichanst., 1 (1): 1–36.

— 1865. Farnkräuter der Jetzwelt. Verlag von Carl Gerold's Sohn. Wien.

FOETTERLE F. 1851. Über die in den Arvaer Comitate in Ungarn befindlichen Braunkohlenablagerungen Jb. Geol. RA, II.

GŁAZEK J. & SZYNKIEWICZ A. 1987. Stratygrafia młodotrzeciorzędowych i staroczwartorzędowych osadów krasowych oraz ich znaczenie paleogeograficzne (Stratigraphy of the Late Tertiary and Early Quaternary karst deposits in Poland and their paleogeographic implications). In: JAHN A. & DYJOR S. (eds.) Problemy młodszego neogenu i eopleistocenu w Polsce. Ossolineum. Wrocław.

GOEPPERT H. 1855. Die tertiäre Flora von Schossnitz in Schlesien. Heyn'sche Buchhandlung. Görlitz.

GRAHAM A. 1965. The Sucker Creek and Trout Creek Miocene floras os Southeastern Oregon, Kent State Univ. Bull., Research Series 9: 1–147.

GREGOR H.-J., KNOBLOCH E., SCHÖTZ M. & UNGER H. J. 1992. Geisenhausen – eine neue Blattfundstelle aus der oberen Süsswassermolasse Bayerns. Doc. Nat. 71: 13–26.

GREUTER W. (ed.) 1988. International Code of Botanical Nomenclature. Adopted by Fourteenth International Botanical Congress, Berlin, July-August 1987. Koeltz Scientific Books.

HALICKI B. 1930. Dyluwialne zlodowacenie północnych stoków Tatr (resumé: La glaciation quaternaire du versant Nord de la Tatra). Spraw. Państw. Inst. Geol., 5 (3–4): 377–534.

HEER O. 1855–1859. Flora tertiaria Helvetiae T. 1–3. Winterthur.

HICKEY L. J. 1973. Classification of the architecture of Dicotyledonous leaves. Amer. J. Bot,. 60.: 17–33.

HOLLICK A. 1930. The Upper Cretaceous flora of Alaska. U.S. Geol. Survey Prof. Paper 159. Washington.

HUZIOKA K. 1972. The Tertiary Floras of Korea. Jour. Mining Coll. Akita Univ. A, 5 (1): 1–83.

ILINSKAYA I. A. 1962. Tortonskaya flora Swoshowitse i pliocenovye flory Zakarpat'ya. Paleont. Zhurn., 3: 102–110.

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

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

JUCHNIEWICZ K. 1975. Flora kopalna Turowa koło Bogatyni w świetle analizy nabłonkowej (summary: The fossil flora from Turów near Bogatynia studied by cuticular analysis). Pr. Muz. Ziemi, 24: 65–132.

KLIMASZEWSKI M. 1988. Rzeźba Tatr Polskich. PWN, Warszawa.

KNOBLOCH E. 1969. Tertiäre Floren von Mähren. Morawské Museum – Musejní Spolek. Brno.

— 1971. Nomenklatorisch-taxonomische Bemerkungen zu *Platanus aceroides* Goeppert und *Quercus attenuata* Goeppert. Mitt. Bayer. Staatssamml. Paläont. Hist. Geol., 11: 263–265.

— & VELITZELOS E. 1987. New leaf floras in the Neogene of Grece. Věstnik Ústř. Úst. Geol., 62 (3): 157–164.

KOLAKOVSKII A. A. 1964. Pliotsenovaya flora Kodora (summary: A Pliocene flora of the Kodor River). Sukh. Bot. Sad. Monogr., 1: 209.

KOTLABA F. 1963. Tertiary plants from three new localities in Southern Slovakia. Sborn. Nár. Mus., B, Přir. Vědy, 19: 53–72.

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

— & KRAINER B. 1990. Faziesentwicklung und Florenabfolge des Aufschlusses Wörth bei Kirchberg/Raab (Pannon, Steirisches Becken). Ann. Naturhist. Mus. Wien, 91/A: 7–38.

KOVÁTS J. 1856. Fossile Flora von Erdöbénye. Arb. Geol. Ges. Ung., 1: 1–37.

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

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

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

OSZAST J. 1970. O wieku utworów stożka Domańskiego Wierchu na podstawie badań palynologicznych (On the age of the Domański Wierch cone determined by palynological methods). Kwart. Geol., 14 (4): 843–846.

OSZAST J. 1973a. The Pliocene profile of Domański Wierch near Czarny Dunajec in the light of palynological investigations (Western Carpathians, Poland). Acta Palaeobot., 14 (1): 1–42.

— 1973b. Analiza palinologiczna osadu ze Starego Bystrego. Archives of the W. Szafer Institute of Botany, Department of Palaeobotany, Pol. Acad. Sc., Kraków. Unpublished.

— & STUCHLIK L. 1977. Roślinność Podhala w neogenie. (summary: The Neogene wegetation of the Podhale (West Carpathians, Poland). Acta Palaeobot., 18 (1): 45–86.

PALAMAREV E. H. 1964. Die geochronologische Entwicklung der neogenen Floren der Balkanhalbinsel. Ber. Geol. Ges. DDR, 9 (3): 301–438.

— & PETKOVA A. S. 1987. Les fossiles de Bulgarie. VIII. 1. La macroflore du Sarmatien Acad. Bulg. d. Sciences, Sofia.

PODBIELKOWSKI Z. 1987. Fitogeografia części świata. T. 1. PWN, Warszawa.

RACIBORSKI M. 1892. Zapiski paleobotaniczne. Kosmos, 17: 526–535.

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

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

SHVAREVA N. Y. 1965. Sopostavlenie flory nizhnevo sarmata s florami verkhnevo tortona raiona L'vova i Predkarpat'ya. Dokl. Akad. Nauk. SSSR, 163(4): 952–955.

— 1983. Miotsenovaya flora Predkarpat'ya. Naukova Dumka. Kiev.

SIKORA W. & WIESER T. 1974. Utwory piroklastyczne w utworach neogeńskich śródgórskiej niecki Orawy-Nowego Targu. Kwart. Geol., 18 (2): 441–443. (in Polish)

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

SZAFER W. 1950. Przewodnik do wycieczki na Podhale XXII Zjazdu Pol. Tow. Geol. w r. 1949 (Guide d'excursion en Podhale de la XXII Réunion de la Société Géologique en 1949). Roczn. Pol. Tow. Geol., 19: 505–508.

— 1952. Młodszy trzeciorzęd Podhala i jego stosunek do pleistocenu (wiadomość tymczasowa). Biul. Państw. Inst. Geol., 56. Warszawa.

TAKHTAJAN A. L., VAKHRAMEEV V. A. & RADCHENKO G. P. 1963. Osnovy Paleontologii. Golosemennye i Pokrytosemennye. Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatel'stvo. Moskva.

UNGER F. 1841. Chloris protogaea. Beiträge zur Flora der Vorwelt. Commision bei Wilhelm Engelmann. Leipzig.

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

— 1850. Genera et species plantarum fossilium. Vindobonae.

— 1860. Sylloge Plantarum Fossilium. Denkschr. Kaiserl. Akad. Wiss., Math.-Naturwiss., 19 (25). Wien.

URBANIAK J. 1960. Wiercenie na Domańskim Wierchu w Kotlinie Nowotarskiej koło Czarnego Dunajca (summary: The borehole at Domański Wierch near Czarny Dunajec, Podhale area). Kwart. Geol., 4 (3): 787–799.

WALTHER H. & ZASTAWNIAK E. 1991. *Fagaceae* from Sośnica and Malczyce (near Wrocław, Poland). A revision of original materials by Goeppert 1852 and 1855 and a study of new collections. Acta Palaeobot., 31 (1–2): 153–199.

WIESER T. 1985. The Teschenite Formation and other evidences of magmatic activity in the Polish Flysch Carpathians and their geotectonic and stratigrafic significance. In: Fundamental Researches in the Western Part of the Polish Carpathians. Guide to excursion 1. Geol. Inst. Poland: 23–36.

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

ZASTAWNIAK E. 1972. Pliocene leaf flora from Domański Wierch near Czarny Dunajec (Western Carpathians, Poland). Acta Palaeobot., 13 (1): 1–75.

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

PLATES

Plate 1

Fagus haidingeri Kováts sensu Knobloch

1. Specimen KRAM-P 136/2
2. Specimen KRAM-P 136/9
3. Specimen KRAM-P 136/11

Zelkova zelkovaefolia (Ung.) Bůžek et Kotlaba

4. Specimen KRAM-P 136/8

Salix sp. div.

5. Specimen KRAM-P 136/12a

Equisetum parlatorii (Heer) Schimper

6. Specimen KRAM-P 136/1

Incertae sedis

7. Specimen KRAM-P 136/10

1–7 – phot. A. Pachoński

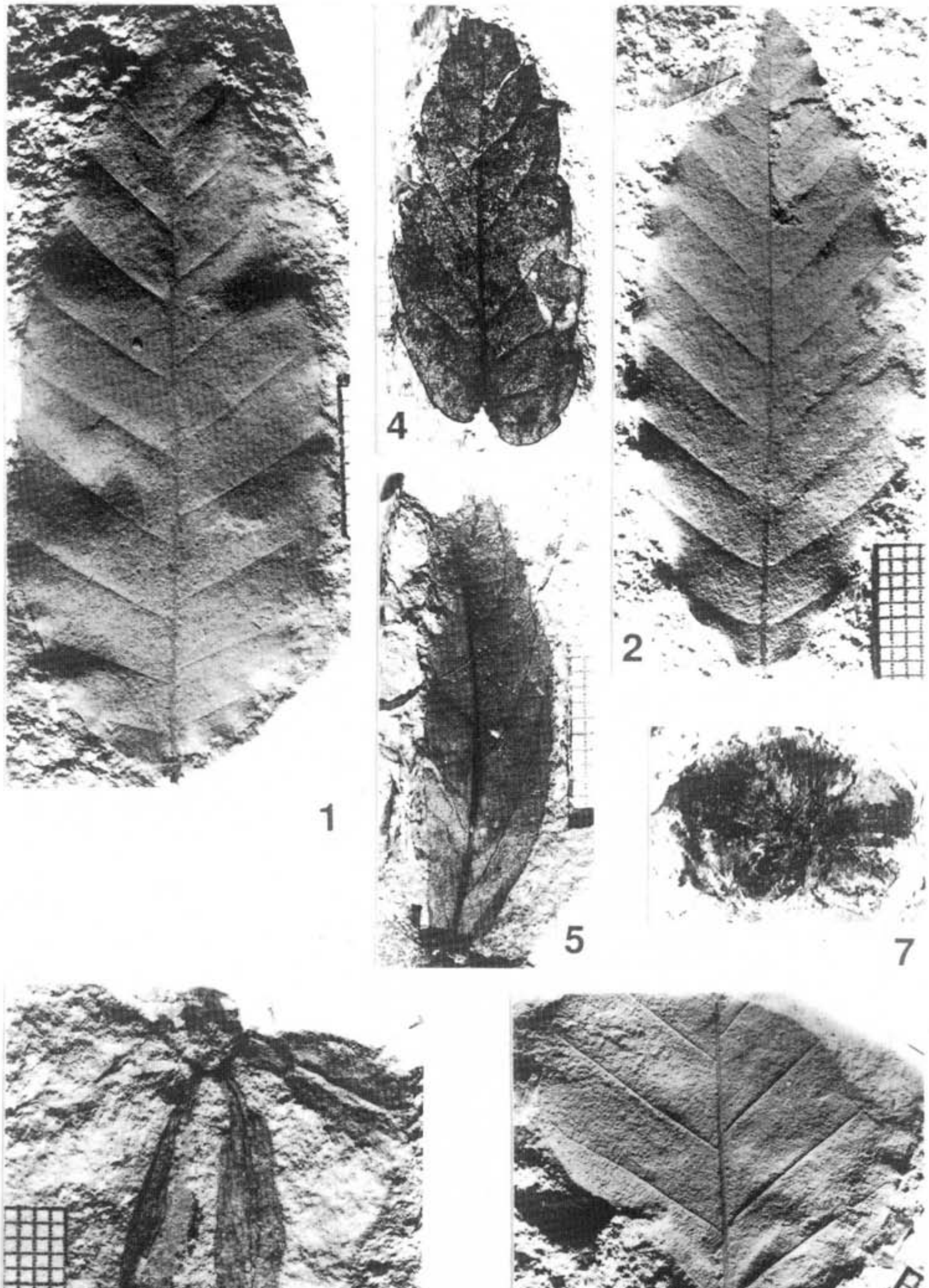

1
4
5
2
7
6
3

Plate 2

Pterocarya paradisiaca (Ung.) Ilinskaya

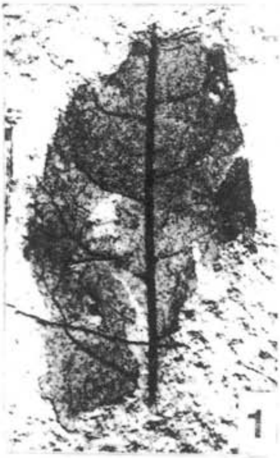
1. Specimen KRAM-P 136/6

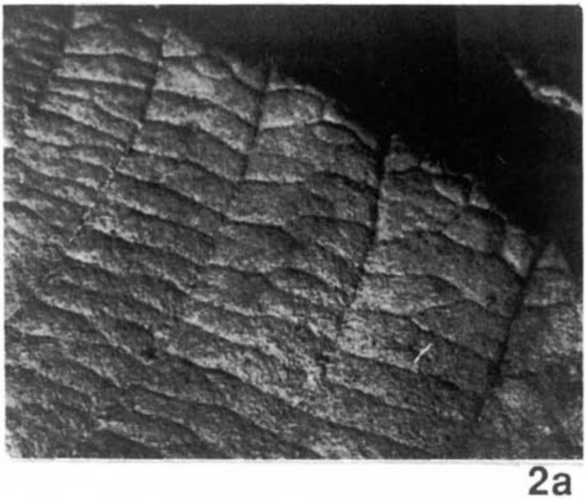
Alnus cecropiaefolia (Ett.) Berger

2. Specimen KRAM-P 136/5

2a. Enlargement of the leaf fragment

1–2a – phot. A. Pachoński





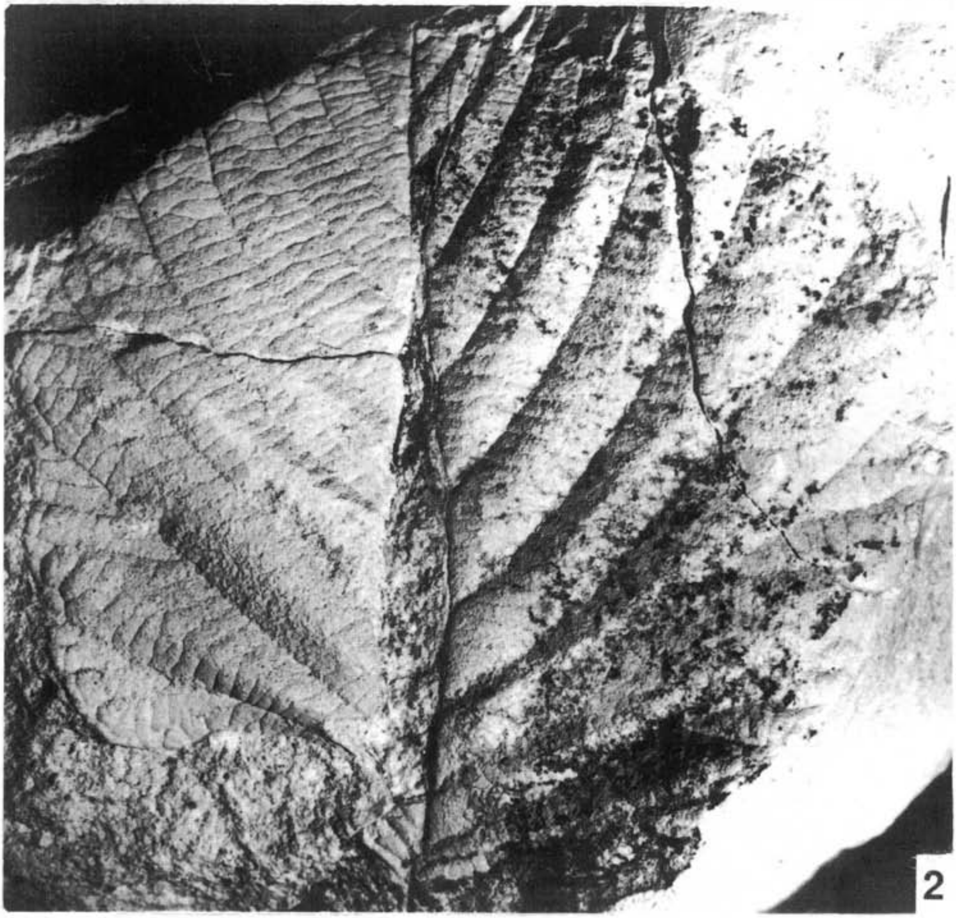


Plate 3

Populus sp.

1. Specimen KRAM-P 136/7

Cornus sp.

2. Specimen KRAM-P 136/17

Zelkova zelkovaefolia (Ung.) Bůžek et Kotlaba

3. Specimen KRAM-P 136/28
4. Specimen KRAM-P 136/4

Polypodiaceae, gen. et sp. indet.

5. Specimen KRAM-P 136/28

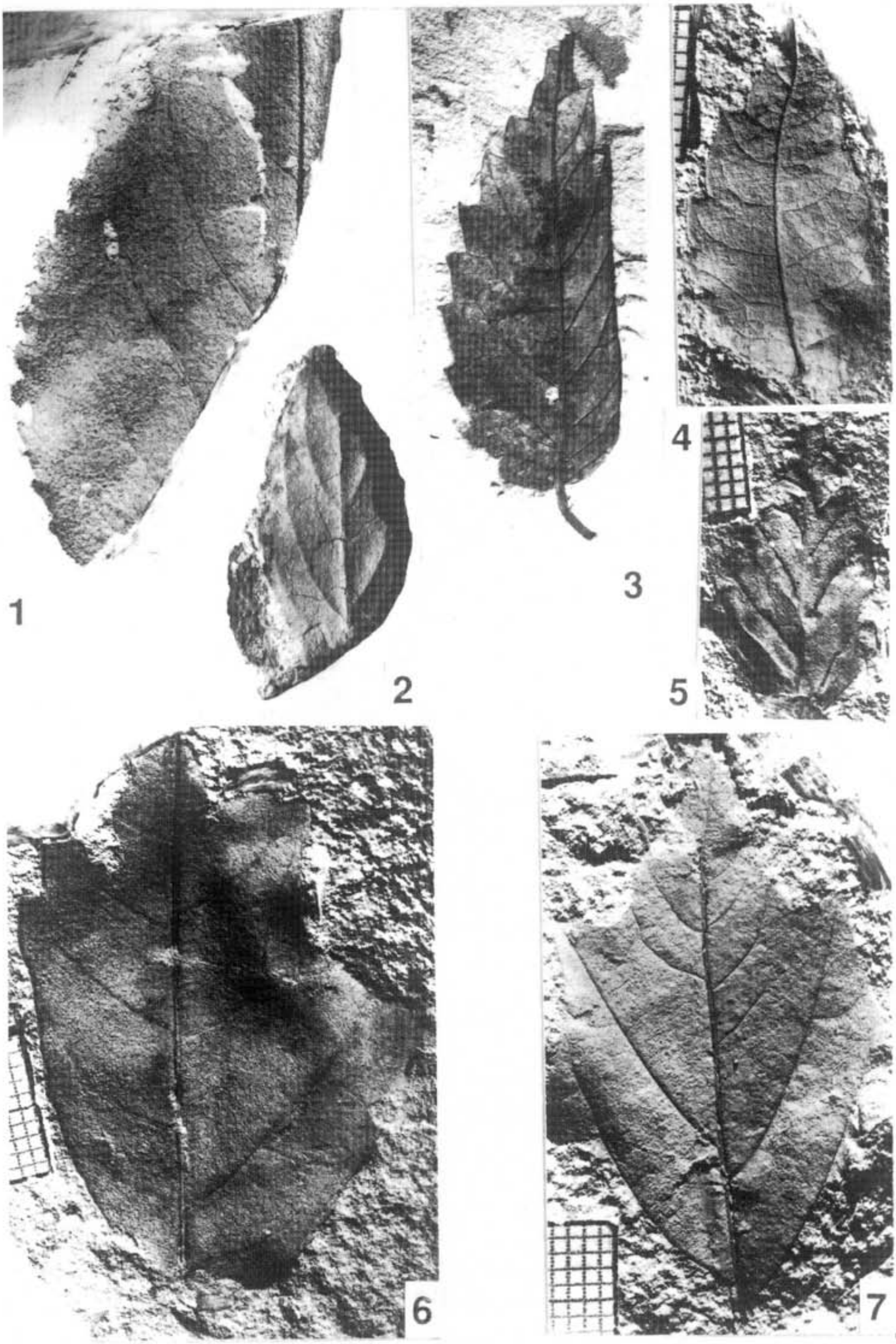
Acer quercifolium (Goepp.) Kovar-Eder

6. Specimen KRAM-P 136/3

Platanus leucophylla (Ung.) Knobloch

7. Specimen KRAM-P 136/3

1–7 – phot. A. Pachoński


1
2
3
4
5
6
7