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THE YOUNGER TERTIARY DEPOSITS IN THE GOZDNICA REGION (SW POLAND) IN THE LIGHT OF RECENT PALAEOBOTANICAL RESEARCH

Edited by
EWA ZASTAWNIAK

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Abstract: The results of geological, lithostratigraphical, palynological and macrofloristic studies of profiles obtained from outcrops and boreholes in the Gozdnica region of south-western Poland are presented. The geological and palynological studies of the Neogene deposits of the rock series (from the Mużaków Series, through the Brown-coal seam Henryk and the Poznań Series to that of Gozdnica) permitted the presentation of a stratigraphical reference profile for the south-western marginal part of the Poznań Series basin in the Sudetic Foreland. On the basis of the fossil fruits, seeds, leaves and shoots present in the deposits of the Gozdnica Series from the Gozdnica and Gozdnica-Stanisław outcrops and on the basis of palynological analysis, the age of the deposits was determined as Pannonian. Mixed *Pinus-Sequoia-Fagus* forest with a significant proportion of the palaeotropical element (33%) and with plants typical of the so-called younger mastixioidean floras, was characteristic the prevailing plant community. The results obtained make it possible to reconstruct changes occurring in the vegetation from the Badenian to the Early Pliocene in western Poland, to determine the climate and palaeogeographical conditions and to date the rock series of the Younger Neogene.

Key words: fruits, seeds, leaves, shoots, wood, inflorescences, sporomorphs, cuticular analysis, younger mastixioidean flora, palaeogeography, biometry, taxonomy, Late Miocene, Lower Silesia, Poland

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CONTENTS

GEOLOGICAL SETTING
(S. DYJOR)

INTRODUCTION

The study area is situated in SW Poland not far from the Polish-German border. It lies in the Lower Silesian lowlands between the Bory Dolnośląskie Upland and the Wrocław-Magdeburg glacier valley and belongs administratively to the Jelenia Góra and Zielona Góra Provinces, between the towns of Bolesławiec and Żary (Fig. 1).

On the geomorphological edge of the Lower Silesian Upland, between the villages Ruszów and Gozdnica, numerous sites containing fossil floras have been located (Fig. 2). In this area, the loam and kaolin clay of the Poznań and Gozdnica Series have been exploited by the brick-clay industry. As a result of prospective drilling and quarrying activity, Tertiary deposits with the fossil floras have been uncovered and exposed. Studies of the Late Tertiary deposits commenced in the sixties when detailed descriptions of the lithostratigraphical units of the Poznań Series and the overlying gravel-sandy deposits of the Gozdnica Series orginally called the series of 'white gravel and kaolin clay', were made (Dyjor 1964, 1966a, b, 1968).

During field explorations of this area within deposits of the Poznań and Gozdnica Series, the author (S. Dyjor) found layers of clay and silt rich in accumulated plant remains, consisting mainly of fruits, seeds and leaf compressions. This interesting material was offered for study to the Palaeobotanical Department of the Wrocław University, with which a cooperation started.

In 1967, samples of the Gozdnica Series (see Fig. 2 & 3, profile 1/67) were collected and examined from the Ruszów section (Stachurska *et al.* 1967). Nearly at the same time another three palaeobotanical sites were exposed: 1. in the Gozdnica clay pit in deposits underlying the Gozdnica Series (see profile 3/71), 2. at the level of grey clay of the Poznań Series (see profile 5) and 3. in the Gozdnica-Stanisław clay pit from the roof part of the Poznań Series (see profile 4/71). The results of the geological and palaeobotanical research were published by Stachurska *et al.* (1971).

In connection with the discovery of new and abundant well preserved fossil leaves, seeds and fruits in this region, further cooperation was started with W. Szafer Institute of Botany, Polish Academy of Sciences, Cracow and the Museum of Earth, Polish Acądemy of Sciences, Warsaw. Reports on the floras from the localities at Gozdnica, Ruszów and Mirostowice Dolne were published in several papers (Sadowska & Zastawniak 1978; Zastawniak 1978; Hummel 1983, 1991; Sadowska 1985a, b; Hummel & Zarzycka 1985; Baranowska-Zarzycka 1988).

The Lower Silesian Branch of the Polish Geological Institute in Wrocław carried out research of the Poznań and Gozdnica Series in the district Ruszów – Gozdnica in the eighties. Later, a new locality with flora was found in the Gozdnica-Stanisław clay pit (Figs 2 & 3, profile 2) and further drilling sections were palynologically evaluated from the Brown-coal seam Henryk (Figs 2 & 3, profile 7) as well as from the top part of the Mużaków Series (Figs 2 & 3, profile 8). This material was studied by the Palaeobotanical Depart-

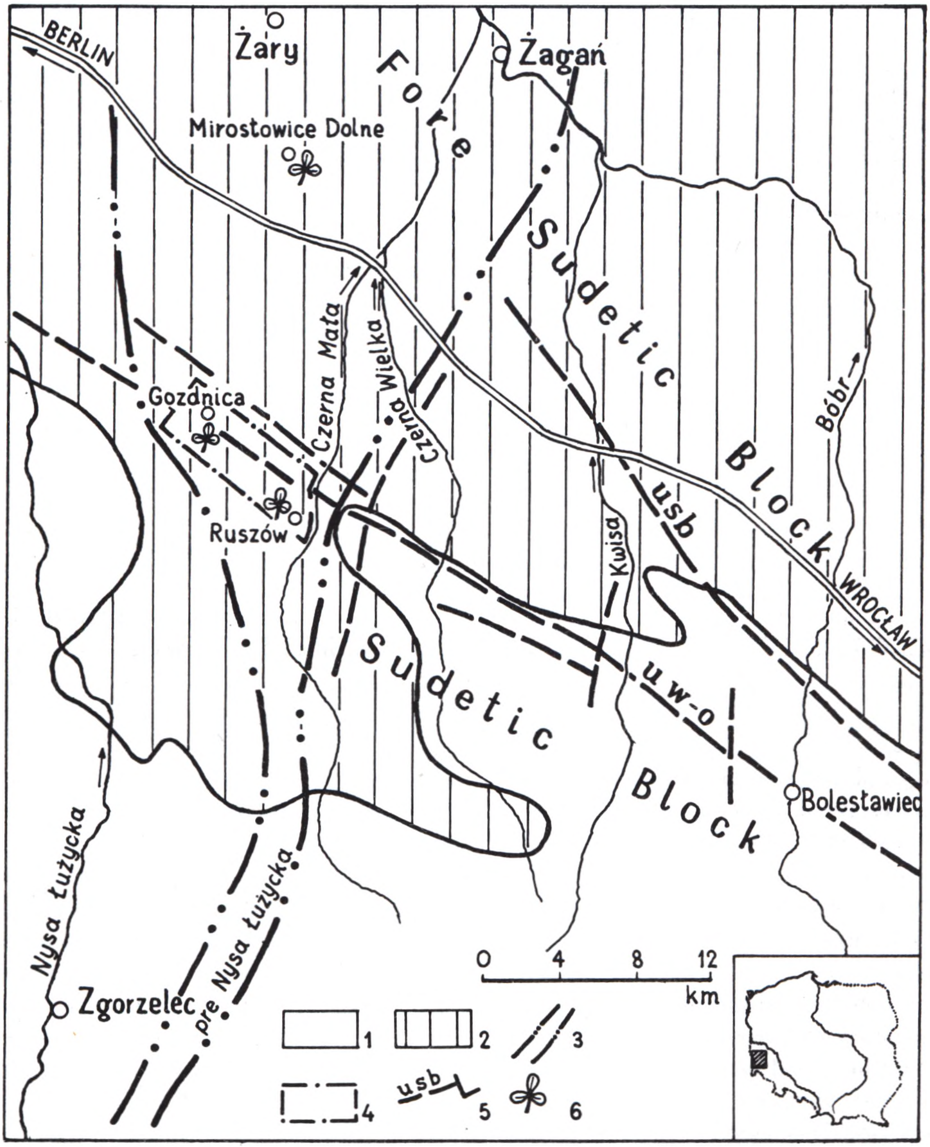


Fig. 1. Palaeogeographical map showing the location of Miocene and Pliocene fossil floras of south-western Poland. 1 – rocks older than the Poznań Series silt; 2 – extent of the Poznań Series silt in the south-western part of the basin; 3 – extent of the Pliocene alluvial fan of the pre-Nysa Łużycka river built of the Gozdnica Series deposits; 4 – the area shown in Fig. 2; 5 – main fault belts active during Tertiary: usb = Middle Sudetic Fault, u W-O = Warta-Osiecznica Fault; 6 –some of the more important localities of fossil floras.

ment of the Wrocław University and W. Szafer Institute of Botany, Polish Academy of Sciences, Cracow, and is published here. Together, the work carried out so far in the Gozdnica – Ruszów region with the results from sections from deposits of the Poznań and Gozdnica Series as well as in the Brown-coal seam Henryk and in the upper part of the Mużaków Series and all dated, by the fossil plant record, make it possible to suggest a stratigraphical synthesis for the Late Tertiary of this region and, therebay, for south-western Poland as a whole (Fig. 3).

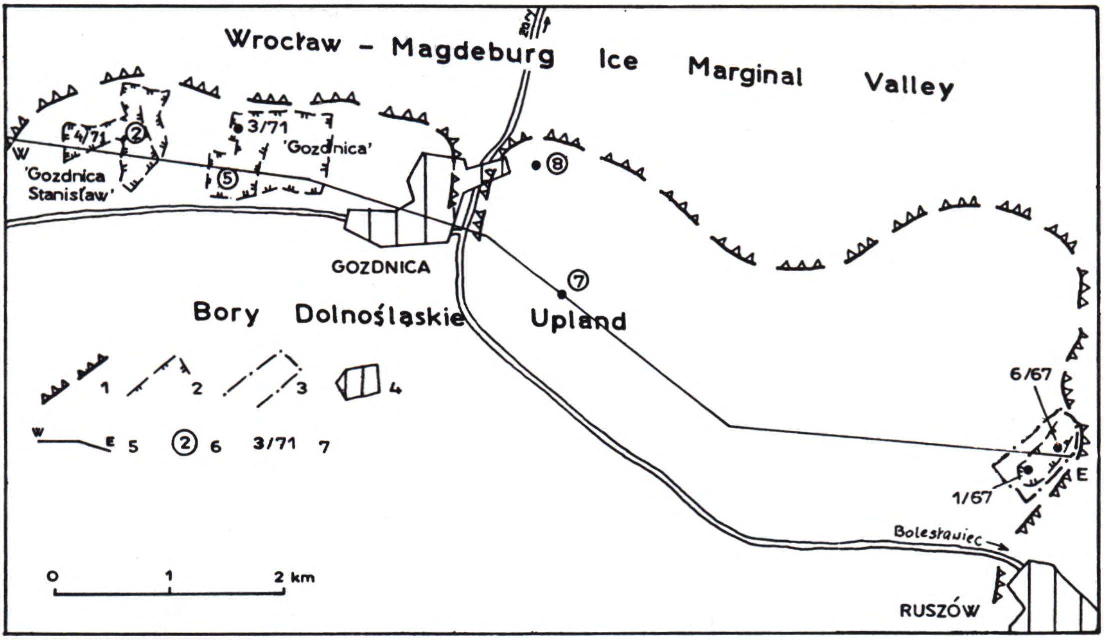


Fig. 2. Situation of outcrops and drillings with fossil flora in the Gozdnica-Ruszów region. 1 – edge of the Tertiary Upland in the Bory Dolnośląskie Upland; 2 – larger clay pits; 3 – the Pliocene flora reserve at Ruszów; 4 – villages; 5 – course of the geological section; 6 & 7 – position of fossil floras in outcrops and drillings: 1/67 – Stachurska *et al.* 1967; ② – Fig. 6, Table 3, Gozdnica-Stanisław C; 3/71 – Stachurska *et al.*, 1971, Fig. 5, and in this paper Table 3, Gozdnica A, Gozdnica B and p. 50; 4/71 – Stachurska *et al.*, 1971, Fig. 4, profile 3; ⑤ – Stachurska *et al.* 1971, Fig. 4, profile 2; 6/67 – Stachurska *et al.* 1967: 355; ⑦ – in this paper Fig. 5, boring GSW/6; ⑧ – in this paper Fig. 5, boring GSW/3.

MIOCENE AND PLIOCENE FORMATIONS IN THE GOZDNICA REGION

The region between Gozdnica and Ruszów has been geologically well recognized on the basis of numerous drillings and outcrops which have almost complete sequences from the Poznań and Gozdnica Series. This region belongs to the marginal part of the Lower Silesian Pine Forest (Bory Dolnośląskie) Upland and is built up of Tertiary deposits. The Gozdnica elevation is cut by a deep old valley of Eopleistocene age and is filled with Quaternary deposits from two earlier glaciations. Shallower accumulations connected with less intensive Quaternary erosion are located in the eastern part of the upland in the Ruszów region (Fig. 4).

Outside the Quaternary erosion zones, the Tertiary deposits are horizontal and are not disturbed by cryoturbation. The extent and variability of deposits can be traced in both the drillings and in the outcrops in the clay pits. Three series and a brown coal seam that separates two of them have been recognized: the Gozdnica Series (Late Miocene – Pliocene boundary), the Poznań Series, the Brown-coal seam Henryk, and the Mużaków Series (Miocene).

Mużaków Series

Only the uppermost part of the Mużaków Series, consisting of silt with coal detritus and passing into the Brown-coal seam Henryk, is discussed here. It is formed by alternating fine grained layers of sand and sandy silt with coal detritus or mica (Figs 3 & 4). In the sandy deposits, glauconite, poorly preserved shells of foraminifers, spikules of sponges, and indeterminable fragments of mollusc shells were recovered. In the palynological profile from the Gozdnica region, marine plankton was also found (Fig. 5).

Brown-coal seam Henryk

In this area the seam Henryk forms thin layers and lenses 1–2 m thick of earthy brown coal containing large quantities of fossil wood and is often strongly sandy and clayey. This description is associated with the southern limits of the seam. Northwards, it increases in thickness and, in the region of Mirostowice it is represented by uninterrupted seam of brown coal 3–4 m in thickness. Variation in thickness and the irregular development of the seam in the Gozdnica region is shown in the geological section (Fig. 4). Several palynological profiles of the brown coal seam were undertaken, from which the profiles at Ruszów and Gozdnica (profiles 6/67 and 7) were described in detail.

Poznań Series

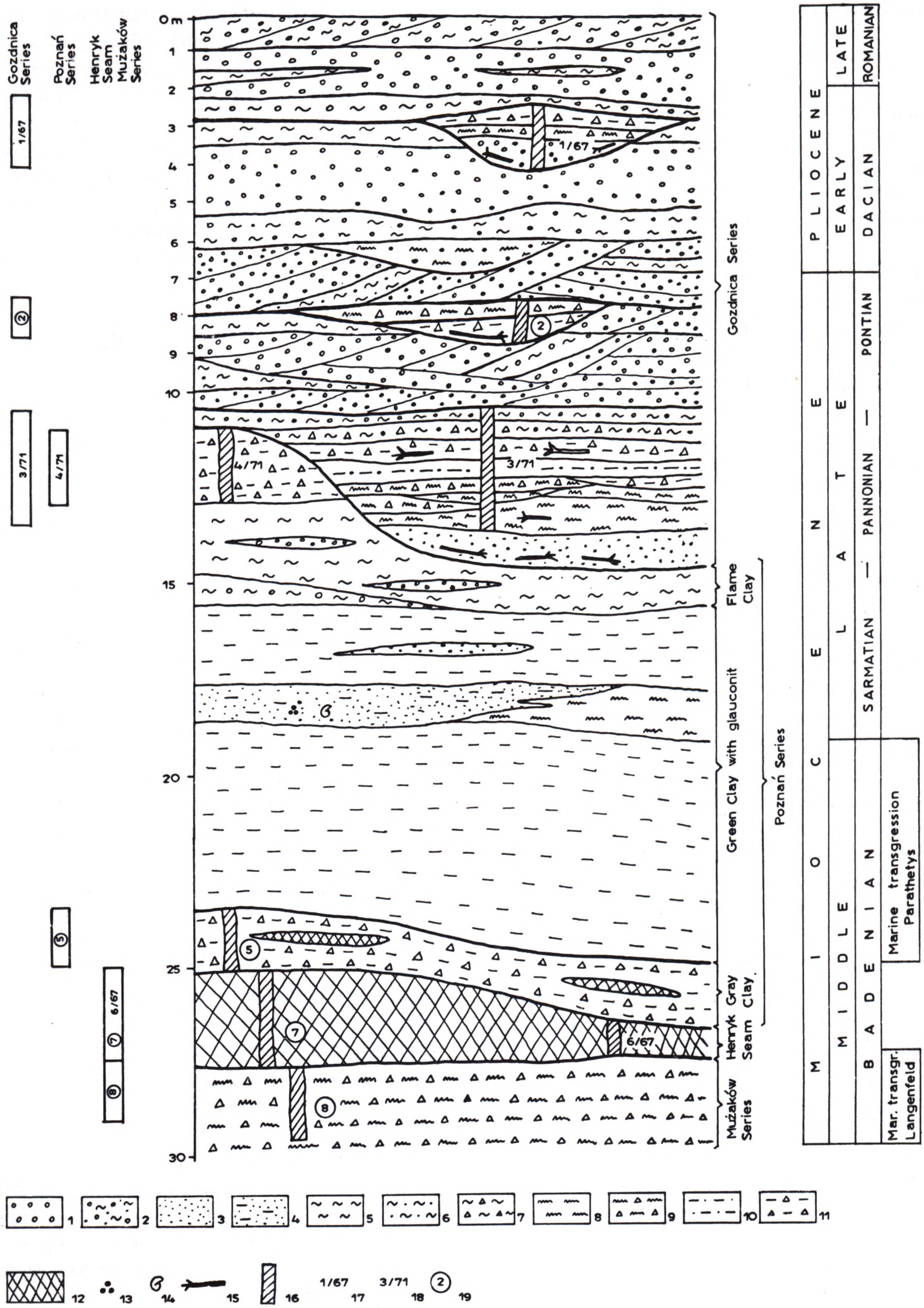
Between Gozdnica and Ruszów this unit forms a marginal zone in the basin and is connected with the Warta–Osiecznica fault belt (Fig. 1) which was active during the Late Tertiary. In connection these conditions, the deposits are comparatively thin (20–30 m) and are characterized by less variable development than those in the lowlands of Lower Silesia. 12 km north of Mirostowice, the deposits of the Poznań Series are over 80 m thick and are developed in the fully characteristic sequence of the Silesian Lowlands.

In the Gozdnica region, three horizons have been recognized within the Poznań Series, which differ in their lithology and origin: the Grey Clay Horizon is very variable in thickness, from a few cm up to 3 m. It is formed by grey and grey-brown clay with coal detritus, or, thin lenses of earthy brown coal, and it contains pieces of fossil wood. A palynological profile has been studied from deposits of this horizon in the Gozdnica outcrop (Fig. 4, profile 2 in Stachurska *et al.* 1971).

The Green Clay Horizon attains a thickness of 10–15 m within the Gozdnica and Ruszów outcrops. It consists of coarse bedded, green and blue layers which contain green sand and silt and is a few metres thick. A large quantity of glauconite and spicules of sponges, indeterminable fragments of mollusc shells and solitary thin-walled shells of foraminifers have been found in sandy deposits at Gozdnica. This indicates the influence of a sea transgression, as is found in the Silesian Lowlands from the environs of Wołów and Strzelin (Łuczkowska & Dyjor 1971). Thus it represents a fixed horizon that allows correlation with other deposits of the Poznań Series from Lower Silesia and links the Gozdnica region with the central part of the basin. It also means that the deposits of the Poznań Series can be dated in terms of the Paratethys Chronostratigraphy.

The Horizon of Flamy Clay, with kaolin grey clay in the upper part, differs slightly in development within the Gozdnica region from that in the central part of the Poznań Series basin. In outcrops and drillings, green-grey and grey clay layers stand out by ferrugineous pockets and by streaks of yellow-brown colour. Higher up, the deposits change into grey kaolin clay with lenses of coarse-grained sand with grits. Such deposits indicate that they originated in a zone of shallow water reservoir, into which fluviatile sandy material and kaolinite were transported. Some places, on sand-bar islets, were covered by vegetation. Remnants of such an islet was found in the Gozdnica-Stanisław clay pit and is represented by coaly grey clay (Fig. 4). These deposits have been found at the top of the Poznań Series and they allow the dating of its upper limit in the Gozdnica region. Gozdnica-Stanisław represents an important palaeobotanical site, which presents the opportunity both to describe environment and to fix the time of extinction of the Poznań Series basin to its south-western extent.

At the end of the sedimentation of the Flamy Clay Horizon in the region of Gozdnica, the influence of a fluviatile environment was considerable. The pre-Nysa Łużycka river entered the basin and formed a vast palaeo-delta. This is indicated by layers of sand, gravel and reworked kaolin clay from the upper part of the Poznań Series. After the retreat of the shoreline of the Poznań Series basin farther northwards, numerous channels subsequently filled by gravel, sand and silt suggest a period of erosion (Figs 3 & 4). Their filling following changes of channel courses was very rapid and nearly immediate in terms of the geological time scale.


Gozdnica Series
Poznań Series
Henryk Seam
Mużaków Series
1/67
2
3/71
4/71
5
6/67
7
8
0 m
1
2
3
4
5
6
7
8
9
10
15
20
25
30
Gozdnica Series
Flame Clay
Green Clay with glauconit
Poznań Series
Gray Clay
Henryk Seam
Mużaków Series
M I O C E N E
P L I O C E N E
M I D D L E
L A T E
E A R L Y
LATE
B A D E N I A N
SARMATIAN — PANNONIAN — PONTIAN
D A C I A N
ROMANIAN
Mar. transgr. Langenfeld
Marine transgression Parathetys
1
2
3
4
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12
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14
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16
1/67 17
3/71 18
2 19

Gozdnica Series

At the end of the Miocene, a period of strong tectonic movements took place, the Walachian phase, which caused the withdrawal of the Paratethys from the northern part of the Carpathian Foredeep and the Polish Lowland Basin of the Poznań Series (Dyjor 1975, 1986). The Sudetic area was raised mainly along the Sudetic border fault and this caused an increasing erosion in the mountains and the accumulation of coarse-grained clastic deposits in the piedmont plains. Consequently, vast alluvial fans of the main Sudetic rivers, including often foreland gravel deposits, were formed (Dyjor 1987).

An extensive alluvial fan of the pre-Nysa Łużycka river accumulated in the Gozdnica region, where gravel, sand and kaolin clay deposits occur in outcrops and in numerous drillings. In the vicinity of Gozdnica and Ruszów these deposits are approximately 20–25 m deep and stretch as far northwards as Żary and Żagań (Fig. 1).

Two phases of sedimentation can be recognized within the Gozdnica Series in the Gozdnica region. The earlier phase is more calmer and is connected with the near-shore facies of the Poznań Series basin. The later one is connected with the maximum accumulations of a fast-flowing stream overloaded with clastic material.

The first phase, which followed directly after the withdrawal of the Poznań Series waters represents a phase of erosion and resulted in a whole system of channels or flat and wide depressions being cut into the Poznań Series deposits (Fig. 3). Following this stream erosion, sand, silt and clay were deposited in these depressions together with fruits, leaves, and washed wood trunks. Examples of the fossil flora from Gozdnica (profile 3/71; see also Fig. 5 in Stachurska *et al.* 1971) and Ruszów (profile 1/67; see also Fig. 3 in Stachurska *et al,* 1967) have been previously studied.

The second phase includes a period of alluvial fan development, when the rapid waters of the pre-Nysa Łużycka river formed vast coarse-grained alluvial deposits. The deposits consist of medium and coarse-grained gravel, quartz-feldspar sand, and strongly weathered feldspar, which is cemented by kaolin, and finally of clay and kaolin silt in shoals. These deposits have the characteristic light-grey colour of kaolin cement and weathered feldspar. This material was deposited by a rapidly flowing river, overloaded with clastic material. This is evident from the gravel-sand deposits with their poor graiding, diagonal bedding, numerous channel structures and presence of transported wooden trunks several meters in length.

Within this strata connected with the alluvial fan, the palynological profiles in the Gozdnica-Stanisław clay pit (see Fig. 6, profile 2) and in Ruszów (profile 1/67 in Stachurska *et al.* 1967) were situated in oxbow deposits. An exact correlation of both sites is difficult as they lie in adjacent areas about 6 km apart. Taking into consideration their relative positioning within the fan, the section 2 at Gozdnica-Stanisław my be slightly older than the one profile at Ruszów (1/67).

The Tertiary sequence is terminated by the Gozdnica Series. During the later periods of the Quaternary, erosion of the Gozdnica Series took place. A system a renewed old valleys arose in Eopleistocene, one of which ran near Gozdnica and a second section of one was found in the Ruszów region (Fig. 4; see also Dyjor 1987).

PALAEOGEOGRAPHY AND DEPOSITIONAL ENVIRONMENT

The Gozdnica region belongs to a peripheral part of the Tertiary basin in the Polish Lowlands and stands within the Warta-Osiecznica fault belt which was active during Tertiary period (Fig. 1). Consequently, the sediment of every unit of clastic

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Fig. 3. Lithostratigraphic sequence of the Miocene and Pliocene deposits in the Gozdnica and Ruszów regions. 1 – gravel; 2 – clayey gravel; 3 – sand; 4 – clayey sand; 5 – kaolinite clay; 6 – sand to kaolinite clay; 7 – clay with coal detritus; 8 – silt; 9 – silt with coal detritus; 10 – sandy clay; 11 – clay with coal detritus; 12 – brown coal; 13 – sand with glauconite; 14 – microfauna; 15 – fossil wood trunks; 16–19 –position of fossil flora in outrcops and drillings (as in Fig. 2).

deposit was partly influenced by: local pre-Tertiary rock exposures in its close vicinity, by uplifts along the afore mentioned fault, and by the influence of the depositional environment of the lowland basin itself. These factors caused the formation of deposits different from those in the centre of the basin, however, they were favourable for the accumulation of numerous lenses and seams of brown coal or coal clay which are rich in plant remains. The proximity of outcropping pre-Tertiary rocks provided local elevations where dry land plant communities, not influenced by floods or damaged by transgressions in the period of the Mużaków and Poznań Series, could survive. The landscape favoured the development of richer and more varied plant communities in this region than in the Silesian Lowland.

Because of the occurrence of valuable clay raw material which have been exploited for centuries, the deposits in the Gozdnica-Ruszów region were well explored both geologically and palaeobotanically. The data obtained to date make it possible to elaborate a standard stratigraphical time-scale for the Late Tertiary of that region and, thereby, for the whole south-western Poland. The research done in the Gozdnica region also encompasses Middle Miocene brackish deposits of the Mużaków Series, connected with the Langelfeld transgression, which began in the North Sea Basin and extended to the western part of the Polish Lowlands. Traces of it have been found in the Brieske Formation in Germany (Lotsch 1968; Dyjor 1986). During the initial investigation of the Mużaków Series in the Gozdnica region, traces of a marine environment were found, as suggested by glauconite in sand, poor and damaged microfauna (which has not been studied in detail till now) and marine plankton from the palynological profile from Gozdnica (Fig. 3, profile 8 and Fig. 5, profile GSW/3). It is possible, therefore, to date the beginning of sedimentation of the Henryk seam in western Poland more precisely. Withdrawal of the marine environment during the deposition of the Mużaków Series proceeded calmly by shallowing of the basin and expansion of the swamps and peat bogs which, in turn, gave rise to the Brown-coal seam Henryk. Transition from the Henryk seam to the Grey Clay Horizon of the Poznań Series took place in similar way. Vast peat bogs were gradually flooded by waters of the Poznań Series which interrupted organic sedimentation. In the deepening basin the Green Clay Horizon began to form. Ingression of the Paratethys Sea started from the north-western part of the Carpathian Foredeep and periodically covered the basin of the Poznań Series. Its influence is traceable within sandy layers by occurrences of glauconite and poor microfauna. This level can be correlated with the central part of the basin of the Poznań Series, where determinable foraminifer fauna allowed to state the Late Badenian age for its counterpart, i.e. the Grabowian Member in the Silesian part of the Paratethys (Łuczkowska & Dyjor 1971; Dyjor 1986).

Within the Poznań Series in the Gozdnica region, a continuous sedimentation from the Grey Clay Horizon through the Green Clay up to Flamy Clay Horizons and kaolin clay can be observed, in spite of their reduction in thickness down to 20–25 m. The palynological profile from Gozdnica-Stanisław (Figs 2 & 3, profile 4/71) dates the time when accumulation of the Poznań Series terminated in this area. When the basin became shallow and when small islets covered with vegetation arose, clay with coal detritus and plant remains were deposited. This palaeobotanical locality is of great importance for establishing the period when the Poznań Series disappeared in the Gozdnica region. Withdrawal of the Poznań Series basin took place earlier in the Gozdnica region than in the central part of the study area and is demonstrated by the different age of the Gozdnica-Stanisław section and Sośnica not far from Wrocław (Stachurska *et al.* 1971, 1973; Dyjor & Sadowska 1986a).

After the retreat of the banks of the Poznań Series basin from the Gozdnica region to the north, loamy deposits started being washed out by the pre-Nysa Łużycka river and gave rise to numerous channels filled with gravel, sand and silt as well as acummulations of fossil plant material. From the geological point of view, these processes were almost simultaneous. This is confirmed by the results of the palynological studies, which found no considerable differences between the flora from the upper part of the Poznań Series

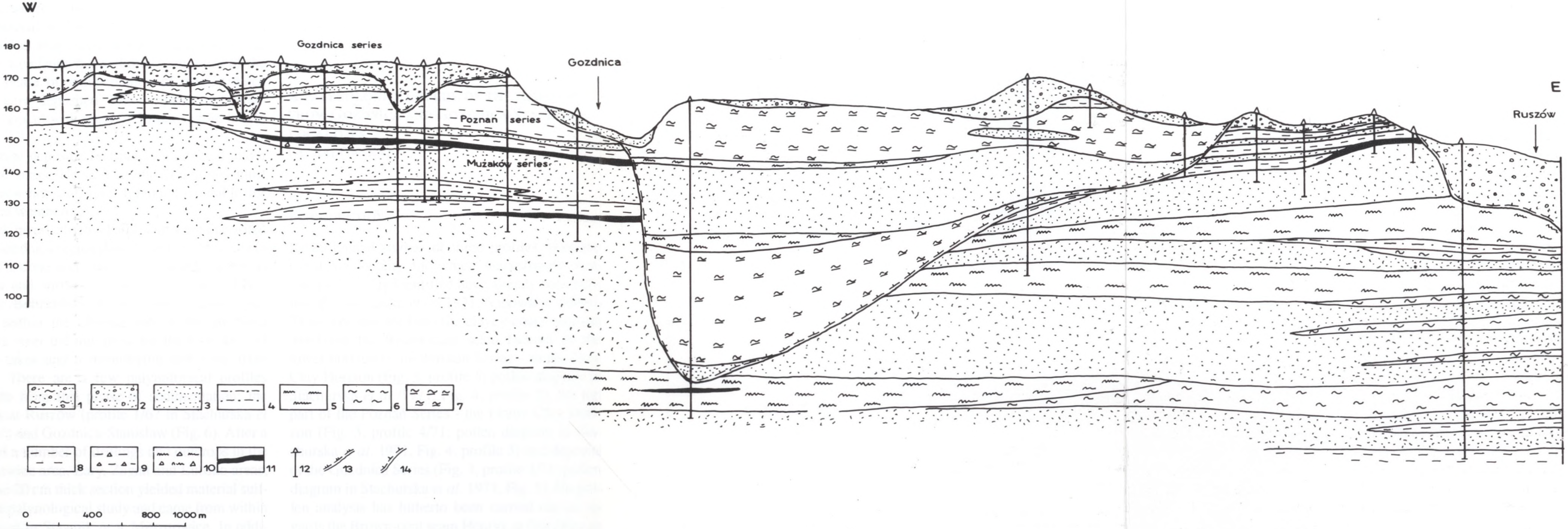

Fig. 4. Geological section of the Tertiary and Quaternary deposits between Gozdnica and Ruszów. 1 – quartz-feldspar gravel of the Gozdnica Series (generalized); 2 – sand with gravel; 3 – sand; 4 – sandy clay; 5 – silt; 6 – kaolinite clay; 7 – grey glacial till – Quaternary; 8 – clay; 9 – clay with coal detritus; 10 – silt with coal detritus; 11 – brown coal; 12 – drillings; 13 – boundary between the Gozdnica and Poznań Series; 14 – boundary between Tertiary and Quaternary levels.

in Gozdnica-Stanisław (Figs 2 & 3, profile 4/71) and the lower part of the Gozdnica Series exposed in the filling of the channel at Gozdnica (Figs 2 & 3, profile 3/71).

Following the increasing uplift of the Sudetic Mts. and the land mass in front, the banks of the Poznań Series basin shifted towards the centre of the basin in the Lubin region, Wrocław and Poznań, where sedimentation continued until the Late Miocene to Early Pliocene. In the mountain areas and in front, erosion intensified and, in the Silesian Lowlands microclastic formations of the second phase of sedimentation of the Gozdnica Series were deposited. They consist of coarse-grained gravel with quartz-feldspar rich in kaolin cement.

In these deposits, feldspar is weathered into a kaolinite mass. Hence climatic conditions must have been hot and quite humid, favourable for chemical weathering.

Thick layers of gravel and sand were deposited in the Gozdnica region during the Late Miocene to Early Pliocene and reached eastwards as far as Ruszów and northwards to Żary, Żagań and Nowogród Bobrzański. Rapid sedimentation processes within the alluvial fan of the pre-Nysa Łużycka river did not allow for the formation of oxbow lakes and a meandering and wide river course. There are a few palynological profiles available from this phase of sedimentation: the profiles at Ruszów (profile 1/67 in Stachurska *et al.* 1967) and Gozdnica-Stanisław (Fig. 6). After a study of a number of drillings and outcrops in the Mirostowice area, Żary, Żagań and Lubsko areas, only one 20 cm thick section yielded material suitable for palynological study and came from within the gravel in Stawnik near Mirostowice. In addition, pieces of fossil wood and a single cone were recovered from Lubsko. The accumulation of deposits in the main mass of the Gozdnica Series occurred in humid and hot climatic conditions and it is confirmed by the results of both geological and palaeobotanical studies. Yet, its highest levels found at Ruszów and Mirostowice must hve been formed in a cooler climate, as suggested by slightly weathered pink feldspar formed occurring there. Perhaps it represents a period of initial cooling between the Pliocene and the Early Quaternary, the Brüggen glaciation (Donau) of northern Europe. It is possible that the deep old erosion valleys from the Eopleistocene, observed in Miocene and Pliocene deposits in the Gozdnica region may be related to the Calabrian regression. A great volume of water was concentrated in glaciers during the oldest Quaternary continental glaciation and this caused global lowering of the sea level. No palaeofloristic dating of that period is available in Lower Silesia.

A PALYNOLOGICAL STUDY OF THE PROFILES FROM GOZDNICA AND GOZDNICA-STANISŁAW LOCALITIES

(A. SADOWSKA)

INTRODUCTION

Palynological studies of three profiles from the Gozdnica locality for which macrofossils were also preliminary identified have already been published (Stachurska *et al.* 1971; Sadowska 1985b). These profiles are from the clayey-coaly deposits overlying the Brown-coal seam Henryk in the lower horizon of the Poznań Series – in the Grey Clay Horizon (Fig. 3, profile 5; pollen diagram in Stachurska *et al.* 1971, Fig. 4, profile 2), the top part of the Poznań Series - the Flamy Clay Horizon (Fig. 3, profile 4/71; pollen diagram in Stachurska *et al.* 1971, Fig. 4, profile 3) and deposits of the Gozdnica Series (Fig. 3, profile 3/71; pollen diagram in Stachurska *et al.* 1971, Fig. 5). No pollen analysis has hitherto been carried out as regards the Brown-coal seam Henryk at Gozdnica as it was not exposed in the outcrops of the brick-clay pit. The borehole material received from the Geological Survey in Wrocław in 1983 permitted palynological studies of several profiles of this coal seam; the present paper is given to one of them (Figs 2, 3 & 5, profile 7). Deposits of the Mużaków Series (Figs 2, 3 & 5, profile 8), underlying the coal, were also studied. Moreover, a new palynological profile of the Gozdnica Series was obtained from the Gozdnica-Stanisław outcrop; leaf remains, wood and a fruit-seed flora were found in these deposits (Figs 2, 3 & 6 and Table 3).

As a result of a new division of the Paratethys Neogene (Steininger & Rögl 1983), the stratigraphy of the localities so far referred to a period between the Late Miocene and the Early Pliocene changed considerably. The fossil floras of these stages are therefore exceedingly important to the stratigraphy of the Neogene, the more so because they are not frequent in Poland. Gozdnica is an unique locality for which it was possible floristically to date the deposits of several geological series of the younger Neogene and to study the changes that had taken place in the vegetation over a marked period of time.

METHODS

Samples of the deposits of the Mużaków Series and those of the Brown-coal seam Henryk were taken from the boreholes. The Mużaków Series is represented in the profile obtained from borehole GSW-3 (Figs 2, 3 & 5, profile 8), from which 13 samples of coaly silts, 4.35 m in thickness, were palynologically studied. Samples were taken at intervals of 20–40 cm. As to the Henryk seam, 6 samples taken at intervals of 0.5 m from the 2.40 m thick profile of borehole GSW-6 (Figs 2, 3 & 5, profile 7) were subjected to a pollen analysis. The profile of the Gozdnica Series (Figs 2, 3 & 6) provided 11 samples, which were taken from the face of the Gozdnica-Stanisław outcrop at intervals of 5 cm.

Coal samples designed for pollen analysis were macerated by boiling in 10% KOH. Following this, the acetolytic method was used. Clay and silt samples were heated in hydrofluoric acid prior to acetolysis. Sporomorphs were counted on 2–4 slides from each sample. The frequency averaged 762 sporomorphs in one sample for the coal, 350 for the Mużaków Series and 538 for the Gozdnia Series deposits.

Absolute values of the taxa sporomophs determined are given for the profile 2 from the Gozdnica Series with the plant macrofossils (Table 1). The percentages of sporomorphs in all the profiles examined are presented in the pollen diagrams (Figs 5 & 6), where values below 0.5% are indicated by the symbol '+'. The taxa noted sporadically are given at the end of the diagrams. The NAP curve is determined by the sum of *Sphagnum* L., *Lycopodium* L., *Selaginella* Beauv. and flowering herbaceous plants.

RESULTS OF THE PALYNOLOGICAL INVESTIGATIONS

Characteristics of vegetation

Profile of deposits of the Mużaków Series

The pollen diagram in Fig. 5 (boring GSW/3) presents a picture of forest vegetation and is demonstrated by a high proportion of sporomorphs of coniferous trees: *Pinus sylvestris* type, *P. haploxylon* type, Taxodiaceae-Cupressaceae with high values of *Sequoia* Endl., *Abies* Miller, *Picea* A. Dietr., *Tsuga* (Antoine) Carrière and *Sciadopitys* Siebold & Zuccarini. *Quercus* L., *Ulmus* L., *Fagus* L., *Betula* L., *Alnus* Miller, *Nyssa* Gronovius, *Engelhardtia* Leschenault, *Carya* Nutt. and *Pterocarya* Kunth. are dominant deciduous trees. The proportion of shrubs in these communities is small and they are chiefly represented by taxa such as *Myrica* L., *Rhus* L., Cyrillaceae-Clethraceae, Ericaceae and Rosaceae. As regards herbs, Polypodiaceae, *Sphagnum* L., *Osmunda* L. and Gramineae are most abundant.

The composition of vegetation is typical of formations originating from sedimentation in extensive water basins, since the pollen grains that prevail here were transported from distnat forest communities growing on drier grounds. Evidence for the presence of the reservoir at that time is provided by the occurrence of pollen grains of *Sparganium* L. and cysts of dinoflagellata and other plankton in the spectrum.

The Mużaków Series is usually built of sporomorph-free sands and, therefore, there are few localities which might be compared with the profile under study. The pollen picture of the upper part of sediments of this series is known from Mirostowice (Sadowska 1977), situated not far from Gozdnica (Fig. 1). The pollen spectra of these two profiles closely resemble each other in composition.

Profile from the Brown-coal seam Henryk

The pollen picture from the brown coal seam (Fig. 5, boring GSW/6) permits a reconstruction of the two communities that played the most important role in the process of coal formation. The dominant community was a shrub swamp which

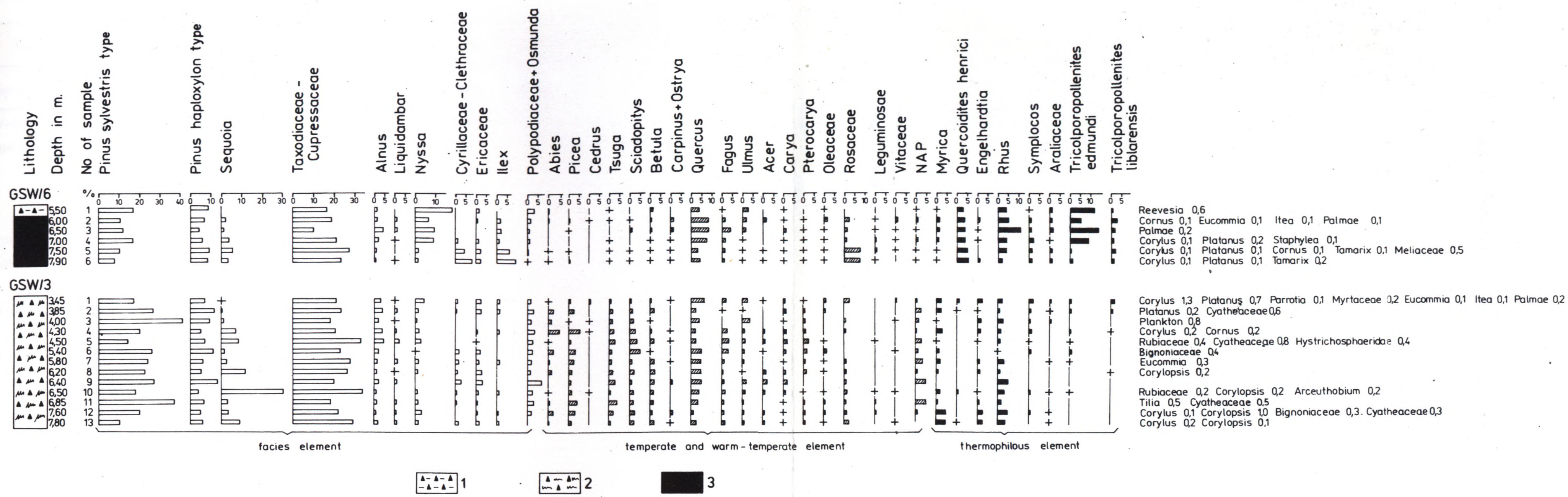

Fig. 5. Pollen diagram of the Mużaków Series (boring GSW/3, see Fig.3, profile ⑧) and Brown coal seam Henryk (boring GSW/6, see Fig. 3, profile ⑦) from Gozdnica. 1 – coal clay; 2 – coal mud; 3 – brown coal.

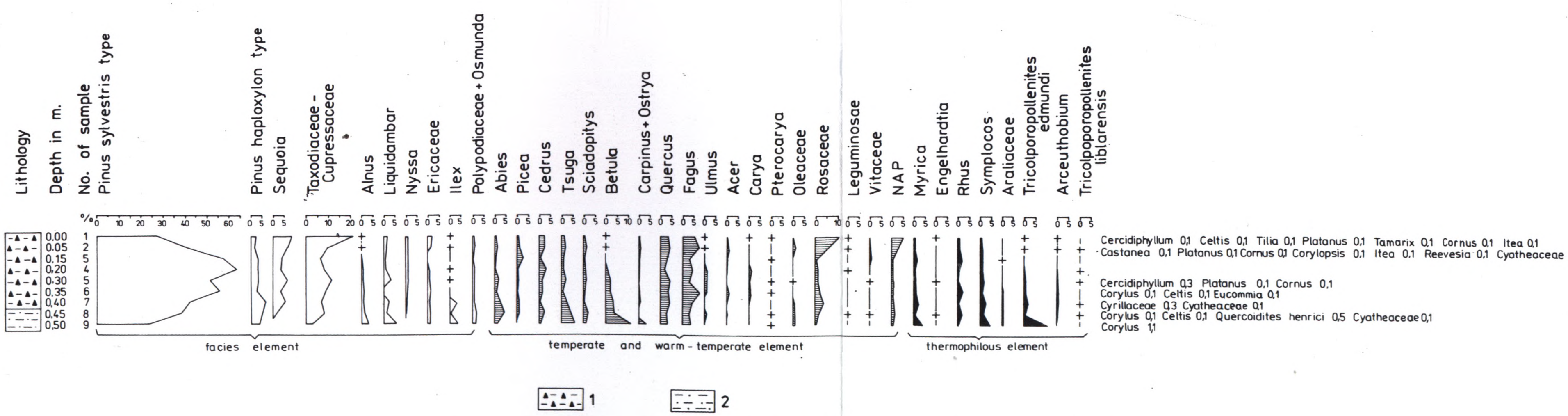

Fig. 6. Pollen diagram of the Gozdnica Series (see Fig.3, profile ②) from Gozdnica-Stanisław. 1 – coal clay; 2 – sandy clay.

Table 1. Gozdnica-Stanisław, profile 2 – number of sporomorphs.

Sample No.	1	2	3	4	5	6	7	8	9	10	11
Sum of sporomorphs	930	660	5	290	–	440	600	600	590	560	170
Pinus sylvestris type	260	270	–	166	–	280	308	335	248	216	40
Pinus haploxylon type	20	11	–	10	–	13	19	15	39	30	7
Abies	2	7	–	2	–	1	10	4	13	24	2
Picea	2	6	–	7	–	1	4	3	5	5	–
Tsuga	13	10	–	3	–	4	11	5	13	21	10
Podocarpus	–	–	–	–	–	–	–	2	–	–	–
Sciadopitys	4	8	–	2	–	3	7	1	1	11	2
Cedrus	22	15	1	2	–	12	9	10	4	12	1
Taxodiaceae-Cupressaceae	200	65	1	18	–	35	70	48	39	44	5
Sequoia	75	44	2	11	–	15	36	20	31	11	–
Glyptostrobus	–	–	–	–	–	1	–	–	–	–	–
Betula	7	4	–	–	–	1	11	13	20	27	20
Alnus	6	2	–	–	–	1	1	5	3	7	5
Ostrya	2	4	–	–	–	1	–	1	3	–	–
Carpinus	1	–	–	1	–	1	2	–	2	–	5
Corylus	–	–	–	–	–	–	–	1	–	1	2
Fagus	52	50	1	30	–	20	18	48	25	18	6
Quercus	37	30	–	9	–	9	25	19	23	15	5
Quercoidites henrici	–	–	–	–	–	–	–	–	–	3	–
Castanea	–	1	–	–	–	–	–	–	–	–	–
Myrica	6	2	–	4	–	1	5	2	10	5	7
Ulmus	7	2	–	–	–	4	6	6	–	5	1
Celtis	1	–	–	–	–	–	–	1	–	1	–
Tilia	1	–	–	–	–	–	–	–	–	–	–
Acer	2	4	–	1	–	1	–	3	2	1	–
Carya	1	–	–	–	–	4	2	3	2	1	–
Pterocarya	2	–	–	1	–	–	2	2	–	2	1
Engelhardtia	1	–	–	–	–	–	2	–	–	1	–
Eucommia	–	–	–	–	–	–	–	1	–	–	–
Buxus	1	–	–	–	–	–	–	–	–	–	–
Platanus	1	1	–	–	–	–	1	–	–	–	–
Arceuthobium	1	1	–	–	–	–	1	1	4	1	–
Liquidambar	13	10	–	2	–	4	17	–	11	8	9
Corylopsis	–	1	–	–	–	–	–	–	–	–	–
Itea	1	1	–	–	–	–	–	–	–	–	–
Cercidiphyllum	1	–	–	–	–	–	2	–	–	–	–
Berberidaceae	–	–	–	–	–	1	–	1	–	–	–
Rosaceae	10	34	–	2	–	5	6	11	20	10	1
Leguminosae	2	2	–	–	–	2	–	–	–	3	–
Nyssa	8	5	–	3	–	4	3	3	2	1	–
Myrtaceae	1	–	–	–	–	–	–	–	–	–	–
Rhus	5	6	–	4	–	3	3	12	4	11	1
Ilex	1	2	–	–	–	2	3	–	14	3	6
Cyrillaceae-Clethraceae	–	–	–	–	–	–	–	–	2	–	–

Table 1. *Continued*

Sample No.	1	2	3	4	5	6	7	8	9	10	11
Vitaceae	2	5	–	2	–	2	1	–	–	2	–
Reevesia	–	1	–	–	–	–	–	–	–	–	–
Cornus	1	1	–	–	–	–	1	–	–	–	–
Araliaceae	–	–	–	1	–	–	–	2	3	2	1
Ericaceae	17	8	–	–	–	2	3	7	5	7	2
Symplocos	6	7	–	3	–	4	10	7	15	12	8
Fraxinus	1	4	–	–	–	–	2	–	–	2	1
Oleaceae	–	1	–	–	–	–	–	–	1	2	1
Caprifoliaceae	–	2	–	–	–	–	–	2	3	5	–
Tricolporopollenites edmundi	1	1	–	–	–	1	1	2	9	5	18
Tricolporopollenites liblarensis	–	2	–	–	–	1	1	–	2	1	–
Sphagnum	1	–	–	–	–	–	–	1	–	–	–
Lycopodium	26	9	–	–	–	–	2	–	–	–	–
Osmunda	1	–	–	–	–	–	2	2	1	–	–
Polypodiaceae	3	6	–	–	–	3	1	1	5	10	3
Cyatheaceae	–	1	–	–	–	–	–	–	1	1	–
Caryophyllaceae	–	–	–	–	–	–	–	–	–	1	–
Labiatae	–	–	–	–	–	–	–	–	–	1	–
Compositae	–	–	–	–	–	–	–	1	–	–	–
Gramineae	11	7	–	–	–	1	1	1	3	9	3
Sparganium	4	–	–	–	–	–	–	–	–	–	–
Monocotyledones indet.	–	1	–	–	–	–	–	–	2	–	–
Indeterminatae	2	2	–	–	–	–	–	2	–	4	2

contained such taxa as *Rhus* L., *Ilex* L., Rosaceae, Cyrillaceae-Clethraceae, Cornaceae [*Tricolporopollenites edmundi* (Potonié) Thomson & Pflug], Araliaceae, *Myrica* L, *Symplocos* Jacquin and Leguminosae. The high percentage of *Quercoidites henrici* (Potonié) Potonié, Thomson & Thiergard pollen in the spectrum is probably connected with this type of community. The other coal-forming community was a swamp forest with *Taxodium* Rich., *Nyssa* Gronovius and *Alnus* Miller. The trees growing on drier grounds, such as *Pinus* L., *Sequoia* Endl., *Fagus* L. or *Quercus* L., formed only a low percentage. They certainly would have covered more elevated areas in the neighbourhood. In conclusion, the pollen profile provides evidence for the existence of extensive marshy and wet areas in the Gozdnica region at the time when the sediments in question were formed.

The spectra presented are typical of the Brown-coal seam Henryk (Brown-coal Lusatian Series I) from the territory of south-western Poland. They are almost identical with the pollen profile of this seam from the Ruszów locality and very similar to other profiles of the Henryk seam from the Żary region (e.g. localities at Mirostowice and Straszów; cf. Sadowska 1977).

In comparison with the profiles of the Mużaków Series, the coal seam shows a decrease in the pollen values of coniferous trees, notably those occurring outside the bog communities. On the other hand, peat-bog plants, especially shrubs, play a more important part here. Those differences are no doubt connected with a change in the facial conditions at the time of the formation of the sediments under study. However, no major stratigraphic differences can be observed here.

Profile of Gozdnica Series sediments from the Gozdnica-Stanisław locality

The general picture of vegetation of the profile from the Gozdnica Series in the Gozdnica-Stanisław outcrop (Fig. 6) shows mainly forest communities which spread in moderately humid and rather dry habitats. These were mixed and deciduous forests with such predominant tree genera as *Pinus*, *Abies*, *Cedrus* Trew, *Sequoia*, *Tsuga*, *Betula*, *Fagus* and *Quercus*. Rosaceae occurred in abundance in the undergrowth. The numbers of swamp and peat-bog taxa are small with *Alnus*, *Liquidambar* L., *Nyssa*, *Ilex*, *Myrica*, *Rhus* and *Tricoloporopollenites edmundi* being dominant among them. They would have certainly belonged to small swamp communities growing along the shores and over cut-off river and stream beds or could have extending around small water basins. Swamp forest with *Taxodium*, *Nyssa* and *Alnus* grew in the wettest places and was invaded by bush swamp with *Myrica* and Ericaceae, while a wet forest with *Liquidambar*, *Carya*, *Pterocarya* Kunth, *Alnus*, *Acer* L., *Ulmus*, *Symplocos*, *Cercidiphyllum* Siebold & Zuccarini, etc. occurred in the vicinity. Plants from the genus *Arceuthobium* Bieb. parasitized on coniferous trees. Some species of pine undoubtedly inhabited swampy grounds or encroached upon peat-bogs, for swamp pine forest is regarded as one of the main types of the Miocene peat-bogs of Central Europe (Schneider 1990). So, the abundant occurrence of pine pollen in the profile, together with the presence of macrofossils, indicates that these trees must have grown in close to where the deposits were sampled for analysis. The proportion of herbs is small in these communities and only grasses and ferns are relatively abundant.

The flora from the Gozdnica-Stanisław outcrop consitutes a different type of community from the fossil vegetation of the same geological series in the neighbouring Gozdnica outcrop (Stachurska *et al.* 1971). This last locality was dominated by the vegetation of wet habitats and peat-bogs: Taxodiaceae-Cupressaceae, *Liquidambar*, *Nyssa*, Cyrillaceae-Clethraceae, *Ilex*, *Symplocos*, etc, reached far higher percentage values. The diagrams for these two localities are thought to reflect different stages in the plant succession.

Age of the profiles from Gozdnica

The Brown-coal seam Henryk and the Grey Clay Horizon of the Poznań Series from Gozdnica overlying it, can be lithologically and palynologically correlated with the Lusatian Series I of the Polish Lowland (Raniecka-Bobrowska 1970). These deposits are also parallelled with the Grabowiec beds of the Silesian part of the Paratethys Basin, and thus their age can be determined as Late Badenian (Dyjor & Sadowska 1986a; Sadowska 1989, 1990). This stage is now included in the upper part of the Middle Miocene (Steininger & Rögl 1983; Dyjor & Sadowska 1986b).

The top part of the Flamy Clay Horizon in the Poznań Series from the Gozdnica-Stanisław outcrop (Fig. 4, profile 3 in Stachurska *et al.* 1971) can be correlated to the Late Sarmatian on the basis of the pollen spectra resembling the diagrams obtained from the Kędzierzyn seam (Dyjor & Sadowska 1977, 1984; Sadowska 1977; Dyjor *et al.* 1978).

A comparison between the profile from the Gozdnica Series in the Gozdnica-Stanisław outcrop with the diagrams of the Henryk seam and the Grey Clay Horizon of the Poznań Series points to a distinct younger age for the deposits of the former series. The representation of the Miocene taxa percentage, especially distnictly thermophilous plants like *Rhus*, *Tricolporopollenites edmundi* (Potonié) Thomson & Pflug and *Tricoloporopollenites liblarensis* (Thomson) Thomson & Pflug is considerbaly lower here; only three pollen grains of *Quercoidites henrici* was noted, while some thermophilous taxa (e.g. Palmae) were missing (Table 2 & Fig. 6). The average values of thermophilous taxa in the Henryk seam are 22% and 6 % in the Gozdnica Series (Table 2). Additionally, such Tertiary plants as Taxodiaceae-Cupressaceae, Cyrillaceae-Clethraceae, *Ilex* and *Nyssa*, have lower values in the profile from the Gozdnica Series, whereas trees of the temperate climate, and especially conifers such as *Pinus sylvestris*, *Abies*, *Picea* and *Tsuga* play a more important part here. *Betula* and *Fagus* are also more abundant.

In comparison to the profile of the top part of the Poznań Series (Fig. 4, profile 3 in Stachurska *et al.* 1971), the profile of the Gozdnica Series presented in this paper, derived from the same outcrop, demonstrates a decrease in the significance of Tertiary taxa: Taxodiaceae-Cupressaceae, *Pinus haploxylon* type, *Liquidambar*, *Nyssa*, *Symplocos*, *Ilex* and *Tricolporopollenites edmundi*. The

Table 2. Average percentage of the stratigraphically significant sporomorphs in the Gozdnica profiles.

Taxon \ Locality	Gozdnica, Brown-coal seam Henryk	Gozdnica, Poznań Series, Grey Clay Horizon	Gozdnica -Stanisław, top of the Poznań Series	Gozdnica -Stanisław, Gozdnica Series	Ruszów, Gozdnica Series
Pinus sylvestris type	12.7	15.3	6.1	44.5	8.3
Pinus haploxylon type	7.2	9.9	21.0	3.5	6.3
Taxodiaceae-Cupressaceae	19.6	19.7	23.1	9.3	8.5
Abies	0.3	0.7	1.2	1.3	0.8
Tsuga	0.2	0.8	0.5	2.2	0.7
Betula	0.6	0.6	0.6	2.8	2.7
Fagus	1.5	2.3	0.7	4.7	1.5
Nyssa	7.7	5.8	3.0	0.6	1.2
Cyrillaceae-Clethraceae	2.4	0.1	0.1	0.03	0.01
Ilex	3.5	1.3	3.5	0.8	0.6
Rhus	5.2	3.4	0.7	1.0	0.1
Symplocos	1.2	2.4	12.0	1.7	0.4
Quercoidites henrici	4.1	–	–	0.05	–
Tricolporopollenites edmundi	7.2	0.4	2.0	1.5	–
Tricoloporopollenites liblarensis	2.0	0.2	0.6	0.1	–
Palmae	0.4	–	–	–	–
Herbaceous plants	0.2	7.0	1.7	1.3	12.0
Thermophilous taxa	22.0	8.5	17.5	6.0	1.0

amount of thermophilous taxa in the Poznań Series was 17.5%, of which 12% fell to *Symplocos*, whereas, in the case of the profile from the Gozdnica Series, as mentioned above, these values were 6% and 1.7% respectively (Table 2). In the Gozdnica Series, however, *Pinus sylvestris*, *Quercus*, *Fagus*, *Betula*, *Abies*, *Picea*, *Tsuga*, etc. reach higher values.

The flora under discussion also appears to be somewhat younger than the profile of the Gozdnica Series from the Gozdnica outcrop, published by Stachurska *et al.* (1971, Fig. 5), in which *Castanea* Miller, Cyrillaceae-Clethraceae, *Ilex*, *Liquidambar*, *Nyssa* and *Symplocos* were more important. Such thermophilous taxa as Actinidiaceae, Rutaceae and Sapotaceae, which are missing from the profile described here, were noted there. Similar amounts of *Pinus sylvestris* type and *Pinus haploxylon* type pollen were found in the profile from the Gozdnica outcrop, while in the Gozdnica-Stanisław profile *Pinus sylvestris* type became prevailed. Despite these differences, the overall picture of vegetation from the Gozdnica Series does not significantly differ from the picture seen in the top layers from the Poznań Series. They both clearly represent the Miocene period. Thus, the end of sedimentation of the Poznań Series and the accumulation of the Gozdnica Series in the Gozdnica region took place as early as the Miocene.

As can be seen from the foregoing comparisons in both outcrops the fossil flora of the Gozdnica Series is much younger than the vegetation of the Henryk seam and the Grey Clay Horizon of the Poznań Series. However, the time of its formation is not very far from the period of sedimentation in the top layers of the Poznań Series, which are considered as Sarmatian. On the other hand, if we compare the pollen flora discussed with the palynological profile of the Gozdnica Series at Ruszów (Stachurska *et al.* 1967, Fig. 3), the nature of the flora from Ruszów is visibly younger. Swamp and forest vegetation with dominant *Alnus*, Taxodiaceae-Cupressaceae, *Nyssa*, *Quercus* and *Ulmus* prevail at Ruszów. The number of thermophilous taxa at Ruszów forms hardly 1% and the proportion of temperate vegtation, notably herbs, is higher there. At Gozdnica, the amount of these last plants averages 0.5% in the Henryk seam and 1.3% in the Gozdnica Series, while in the profile from Ruszów it is 12%. The flora from Ruszów can be referred to the Middle Pliocene or the upper part of the Early Pliocene (Hummel 1983; Sadowska 1985a, 1987).

The comparisons presented above show that, in both outcrops, the pollen flora of the sediments of the Gozdnica Series is younger than Sarmatian and older than Early Pliocene. It is Miocene in character and so its age may be fixed at the Late Miocene. The lack of dated deposits from the uppermost part of the Miocene in Poland does not allow for the exact determination of the stage at which the sediments under study were formed. Nevertheless, their age may be theoretically assumed to fall within the Pannonian-Pontian interval.

In Poland, the palynological picture of vegetation representing these stages is known from the Podhale region (northern section of the Central Paratethys). It is characterized by a significant change of plant communities: the participation of Tertiary genera decreases and gives way to elements of a more moderate climate, for example, spruce appears and the participation of pine, alder and of herbaceous plants increases (Oszast 1973; Oszast & Stuchlik 1977; Stuchlik 1980, 1987).

The flora from Gozdnica supports the palynological data obtained from the Central Paratethys, namely in that the Early Pannonian climate was very similar to the earlier Sarmatian one. It is difficult, therefore, discriminate between these periods on the basis of palynological criteria (Planderová 1972, 1990). Swamp forests and abundant *Fagus* continued to be characteristic of the Early Pannonian in this area. These swamp forests did decay gradually and were replaced by forests with *Pinus*, *Sequoia*, *Tsuga*, *Fagus*, *Quercus*, *Betula* and *Ulmus*. In the Central Paratethys the Pannonian climate was warmer than the climate in Poland and its floras still abound with numerous subtropical genera (Planderová 1972, 1978, 1990; Nagy 1990a, b). Likewise, in northwestern Europe, the pollen floras from the Miocene/Pliocene boundary (Susterian-Brunssumian) also give a warmer picture in spite of great similarities to the vegetation of the Gozdnica Series from the localities at Gozdnica. They are characterized by the dominance of *Pinus* and a remarkable amount of *Sequoia*, *Tsuga*, *Quercus*, *Ulmus* and *Fagus*, but at the same time contain a notable proportion of thermophilous plants (Brelie 1974; Zagwijn 1960, 1966, 1974, 1986; Menke 1975; Suc & Zagwijn 1983).

The above-quoted data indicate the similar nature of the changes occurring in the plant cover of Central Europe towards the end of the Miocene, despite certain regional differences. They were marked by a decrease in the role of swamp forests and peat-bogs in favour of mesophilous mixed and deciduous forests and were accompanied by a simultaneous decrease in thermophilous genera. The profiles from Gozdnica provide clear evidence that these changes were less distinct on the Sarmatian/Pannonian boundary than on the Badenian/Sarmatian boundary.

The pollen profiles from Gozdnica confirm Gregor's (Gregor & Velitzelos 1987; Gregor 1990) opinion that there are no floristic signs that the climate in Central Europe became dryer towards the end of the Miocene (so-called Messinian crisis). All the Late Miocene floras from southwestern Poland are essentially wet in nature and provide evidence for the dominance of mesophilous and wet forests, the presence of swamp forests and the complete lack of indicators signifying a change towards a steppic climate.

MACROSCOPIC PLANT REMAINS FROM THE GOZDNICA AND GOZDNICA-STANISŁAW LOCALITIES

(M. ŁAŃCUCKA-ŚRODONIOWA, Z. KVAČEK AND E. ZASTAWNIAK)

INTRODUCTION

The macroscopic flora dealt with in the present paper comes from deposits occurring in two outcrops of the Gozdnica Series. Two assemblages were obtained from one outcrop in the Gozdnica clay-pit (Figs 2 & 3, profile 3/71). The first assemblage (Table 3, Gozdnica A) consists of plant remains whose determinations were published in 1971 (Stachurska *et al.* 1971). Two genera had to be crossed off the list of 21 taxa given in that paper. The seeds described as *Nuphar* sp. (No. MGUWr 6562p, Geological Museum, Wrocław University) do not belong to this genus and the determination *Menyanthes trifoliata* L. fossilis is incorrect. It is, most probably, a zoocecidium. Some endocarps referred to the Araliaceae belong in fact to the species *Pentapanax tertiarius* Mai and the stones regarded as *Cornus* sp. have been allocated to the genus *Swida* Opiz. The remains from the genera *Vaccinium* L., *Ilex* L., *Ludwigia* L., *Trichophorum* Pers. and the majority of *Carex* L. fruits have been identified to species. Fragmentary of *Gleditsia knorrii* (Heer) Gregor pods were distinguished from amongst the previously undetermined material.

The second assemblage of fruits and seeds (Table 3, Gozdnica B) was derived from the same profile 3/71 (Figs 2 & 3), in the Gozdnica clay-pit. As many as 2904 remains, belonging to 46 taxa, were obtained from a small box (10 x 6 x 1 cm) of washed plant detritus. These materials were identified by M. Łańcucka-Środoniowa in 1971 but have not been published yet.

Further remains were collected from profile 3/71 in the Gozdnica clay-pit in 1991. They, too, comprise of numerous fruits and seeds, determined preliminarily by M. Łańcucka-Środoniowa, and will be given in a separate paper. Now they are taken into consideration only in the chapter concerning the dating of macrofossil flora from Gozdnica (p. 50) and in Table 5. A pollen diagram of profile 3/71 made by A. Sadowska is presented in Fig. 5 in a paper by Stachurska *et al.* (1971).

The other outcrop with macroscopic remains also lies within deposits from the Gozdnica Series but was recovered from the Gozdnica-Stanisław clay-pit (cf. p. 9, Figs 2 & 3). Profile 2, obtained from this horizon in 1986, provided many fuits, seeds and, for the first time, leaf compressions and fossil wood. These remains make up a third assemblage (Table 3, Gozdnica-Stanisław C). It numbers 2861 remains, and represents 58 taxa. A pollen diagram of profile 2, made by A. Sadowska, is given in Fig. 6 and discussed on p. 16.

M. Łańcucka-Środoniowa identified the carpological remains (Table 3, Gozdnica B and Gozdnica-Stanisław C), Z. Kvaček (Prague), determined and described the conifers, pollen grains of *Pinus* and *Fagus* (SEM) and the epidermis of dicotyledonous leaves, E. Zastawniak (Cracow) studied the morphology of the leaves and M. Białobrzeska (Cracow) analysed variability of the fruits of *Fagus microcarpa* Miki *emend.* Uemura. The fossil wood was identified and described by W. Pyszyński (Wrocław).

The fossil material is currently housed in the Geological Museum, Wrocław University (MGUWr), and in the Palaeobotanical Museum of the W. Szafer Insttute of Botany, Polish Academy of Sciences, Cracow (KRAM-P, No. 83).

The photographs were taken by J. Brožek and Z. Kvaček (Prague), Li Hao-min (Nanijng), A. Pachoński (Cracow) and W. Pyszyński (Wrocław). The drawings were made by M. Łańcucka-Środoniowa (Figs 12–17) and J. Wieser (Figs 7–11 & 18).

LIST OF MACROFOSSILS

The vast majority of the plant macrofossils are fruits and seeds, however, there are also leaf compressions and impressions, detached leaves and leaf fragments, leaf fascicles, brachyblasts, leaf whorls, twigs, buds, inflorescences, cone fragments, male cones with their pollen *in situ*, cone scales, needles and wood.

A list of the identified carpological remains and leaf compressions (except wood) obtained from the Gozdnica and Gozdnica-Stanisław clay-pits is given in Table 3. It comprises 7 taxa of the Cryptogammae, 9 of the Gymnospermae and 79 of the Angiospermae, of which 53 are dicotyledonous and 26 are monocotyledonous plants. The macrofossils found at Gozdnica (3/71) in 1991 are neither included in Table 3 nor discussed in the systematic part. They are fossil fruits and seeds of the following genera: *Eurya* Thunberg, *Symplocos*, *Styrax* L., *Sphenotheca* Kirchh., *Eomastixia* Chandler, *Tetrastigma* Planchon, *Carya*, *Acer* and *Magnolia* L. and will be dealt with in a separate paper.

Arceuthobium oxycedroides Łańcucka-Środoniowa, *A. tertiaerum* Łańcucka-Środoniowa, *Clethra friisii* Łańcucka-Środoniowa and *Trichopho-*

Table 3. Macroscopic plant remains found in the clay pit at Gozdnica, profile 3/71: Gozdnica A – Stachurska *et al.* 1971, Gozdnica B – Łańcucka-Środoniowa, unpubl., and in the clay pit Gozdnica-Stanisław C, profile ②.
Fossil fruits and seeds found in Gozdnica in 1991 (see p. 50) as well as fossil wood are not included in this Table.
[x] *det.* M. Łańcucka-Środoniowa, non applicated by Stachurska *et al.* 1971.

	Taxon	Gozdnica A	Gozdnica B	Gozdnica -Stanisław C	Total
	Cryptogamae				
1.	*Cenococcum graniforme* (Sow.) Ferd. & Winge	–	–	15	15
2.	*Trematosphaerites lignitum* (Heer) Beck	–	–	7	7
3.	Microthyriaceae gen.	–	–	1	1
4.	Fungi gen. div.	–	8	5	13
5.	*Azolla filiculoides* Lamarck fossilis	–	1	–	1
6.	*A. tomentosa* Nikitin	–	–	3	3
7.	*Selaginella pliocenica* Dorofeev	–	–	1	1
	Coniferae				
8.	*Pinus* (*Pinus*) cf. *brevis* Ludwig	–	3	47	50
9.	*Pinus* (*Pinus*) cf. *spinosa* Herbst	–	4	11	14
10.	*Pinus* (*Strobus*) *leitzii* Kirchheimer	∞	714	368	∞
11.	*Tsuga* (*Tsuga*) sp.	–	–	3	3
12.	? Pinaceae gen et sp. indet.	–	12	–	12
13.	*Sequoia abietina* (Brongn.) Knobloch	∞	1160	629	∞
14.	*Taxodium dubium* (Sternb.) Heer	–	55	81	136
15.	*Tetraclinis salicornioides* (Unger) Kvaček	1	–	42	43
16.	Cupressaceae gen. et sp.	–	–	2	2
	Angiospermae – Dicotyledones				
17.	cf. *Ceratophyllum* sp.	–	–	1	1
18.	cf. *Stellaria* sp.	–	–	1	1
19.	*Chenopodium album* L. fossilis	–	–	1	1
20.	*Rumex* sp.	–	–	1	1
21.	*Liquidambar* sp.	–	4	–	4
22.	*Fagus silesiaca* Walther & Zastawniak var. *gozdnicensis* Zastawniak & Kvaček, *var. nov.*	–	–	59	59
23.	*Fagus microcarpa* Miki *emend.* Uemura	1106	321	985	2424
24.	*Fagus* sp.	–	–	+	+
25.	*Betula longisquamosa* Mädler	–	4	141	145
26.	*B. subpubescens* Goeppert	–	–	2	2
27.	cf. *Betula* sp.	–	1	18	19
28.	*Carpinus moldavica* Negru	–	1	6	7
29.	*Ostrya szaferi* Mai	–	–	2	2
30.	*Myrica ceriferiformis* Kownas	1	–	17	18
31.	*Eurya stigmosa* (Ludwig) Mai	1	–	2	3
32.	*'Viburnum' atlanticum* Ettingshausen	–	–	1	1
33.	*Symplocos lignitarum* (Quenstedt) Kirchheimer	8	–	1	9
34.	*S. minutula* (Sternberg) Kirchheimer	3	–	–	3
35.	*Hypericum* sp. 1	–	19	1	20
36.	*Hypericum* sp. 2	1	–	–	1

Table 3. *Continued*

Taxon	Gozdnica A	Gozdnica B	Gozdnica -Stanisław C	Total
37. *Hypericum* sp. 3	34	–	39	73
38. *Hypericum* sp.	3	–	–	3
39. *Clethra friisii* Łańcucka-Środoniowa, *sp. nov.*	–	3	–	3
40. *Andromeda carpatica* Łańcucka-Środoniowa	–	1	–	1
41. *A. nigra* Dorofeev	–	8	–	8
42. cf. *Enkianthus* sp.	–	1	–	1
43. cf. *Lyonia* sp.	–	2	–	2
44. *Vaccinium minutulum* Łańcucka-Środoniowa	–	3	–	3
45. *Vaccinioides lusatica* (Litke) Kvaček & Walther	–	–	1	1
46. cf. *Pirocarpella aquisgranensis* Mai	–	–	20	20
47. *Boehmeria sibirica* Dorofeev	–	–	1	1
48. *Aldrovanda praevesiculosa* Kirchheimer	–	8	–	8
49. cf. *Alchemilla* sp.	–	–	1	1
50. *Rubus microspermus* C. & E. M. Reid	–	–	9	9
51. *Rubus* sp.	–	–	1	1
52. *Melastomites tertiaria* Dorofeev	–	26	19	45
53. *Microdiptera menzelii* (E. M. Reid) Mai	–	1	–	1
54. *Ludwigia* cf. *corneri* Friis	–	4	–	4
55. *L. palustris* (L.) Elliot fossilis	2	55	–	57
56. *Proserpinaca brevicarpa* Dorofeev	–	–	8	8
57. *Gleditsia knorrii* (Heer) Gregor	6^x	3	–	9
58. *Ilex saxonica* Mai	4^x	2	–	6
59. *Arceuthobium oxycedroides* Łańcucka-Środoniowa, *sp. nov.*	–	23	–	23
60. *A. tertiaerum* Łańcucka-Środoniowa, *sp. nov.*	–	7	–	7
61. *Arceuthobium* sp.	–	246	–	246
62. *Viscum miquelii* (Geyler & Kinkelin) Czeczott	336	83	115	534
63. *Paliurus* cf. *ramosissimus* Poiret	–	–	3	3
64. *Nyssa disseminata* (Ludwig) Kirchheimer	4	–	–	4
65. *Swida* sp.	2^x	–	–	2
66. *Tectocarya lusatica* Kirchheimer	–	1	–	1
67. *Pentapanax tertiarius* Mai	8^x	11	–	19
68. Araliaceae gen.	8	–	–	8
69. cf. Labiatae gen.	–	–	1	1
Angiospermae – Monocotyledones				
70. *Alisma* ex gr. *plantago* L. fossilis	–	3	–	3
71. cf. *Sagittaria* sp.	–	14	–	14
72. *Smilax* sp.	–	–	1	1
73. *Juncus* sp.	4	1	2	7
74. *Carex caespitosa* L. fossilis	–	8	–	8
75. *C. elongatoides* Łańcucka-Środoniowa	–	10	–	10
76. *C. flavaeformis* Łańcucka-Środoniowa	–	–	4	4
77. *C.* cf. *plicata* Łańcucka-Środoniowa	–	–	88	88
78. *C.* cf. *ungeri* Mai	–	–	6	6

Table 3. *Continued*

Taxon	Gozdnica A	Gozdnica B	Gozdnica -Stanisław C	Total
79. *Carex* sp. 1	–	2	–	2
80. *Carex* sp. 2	–	1	–	1
81. *Carex* sp.	1	–	–	1
82. *Caricoidea globosa* (C. & E. M. Reid) Mai	–	45	8	53
83. *Cladium* sp.	–	–	1	1
84. *Cyperus* sp.	–	10	–	10
85. *Dulichium arundinaceum* (L.) Britton fossilis	2	–	5	7
86. *D. marginatum* (C. & E. M. Reid) Dorofeev	–	–	9	9
87. *Trichophorum silesiacum* Łańcucka-Środoniowa, *sp. nov.*	1	–	26	27
88. *Scirpus sylvaticus* L. fossilis	–	–	15	15
89. *S. ragozinii* Dorofeev	–	1	20	21
90. cf. Gramineae gen.	–	2	–	2
91. *Epipremnites reniculus* (Ludwig) Mai	–	–	1	1
92. *Sparganium* cf. *nanum* Dorofeev	–	1	–	1
93. *Typha* sp.	–	–	1	1
94. *Carpolithes natans* Nikitin *ex* Dorofeev	10	7	2	19
95. *Carpolithes* sp.	–	4	–	4
Total	∞	2904	2861	∞

rum silesiacum Łańcucka-Środoniowa are new species and *Andromeda nigra* Dorofeev, *Carex caespitosa* L. fossilis, *Carex* cf. *ungeri* Mai, *Carpinus moldavica* Negru, *Fagus microcarpa* Miki *emend.* Uemura, *Ilex saxonica* Mai, *Ludwigia* cf. *corneri* Friis, *Ostrya szaferi* Mai, cf. *Pirocarpella aquisgranensis* Mai, *Proserpinaca brevicarpa* Dorofeev, *Scirpus ragozinii* Dorofeev *Vaccinioides lusatica* (Litke) Kvaček & Walther and *'Viburnum' atlanticum* Ett. new taxa to the Tertiary of Poland. A variety *Fagus silesiaca* Walther & Zastawniak var. *gozdnicensis* Zastawniak & Kvaček is also distinguished. Fossil wood of *Quercus* are described for the first time from the Tertiary of Poland and fruits of *Fagus microcarpa* Miki *emend.* Uemura for the first time from the European Neogene.

The perfect state of preservation of the material is striking, the plant remains are undeformed, undamaged and bear no traces of long-distance transport. The whole assemblage is highly allochtonous but its source must have been situated near the place of deposition, in view of the fact that the plant remains are so well preserved and, furthermore, some leaf remains (*Fagus, Betula, Viscum* L.) were also found.

SYSTEMATIC PART OF THE MACROFOSSILS

Fungi

Family: **Agonomycetaceae**

Cenococcum graniforme (Sow.) Ferd. & Winge

Lycoperdon graniforme Sow. (Sowerby 1800, Pl. 270)
Cenococcum graniforme (Sow.) Ferd. & Winge (Ferdinandsen & Winge 1925: 332)
Cenococcum graniforme (Sow.) Ferd. & Winge (Ławrynowicz 1983: 31; Fig. 1)

Material. Gozdnica-Stanisław No. 83/184: 15 sclerotia.

Family: **Amphisphaeriaceae**

Trematosphaerites lignitum (Heer) Beck

Sphaeria lignitum Heer (Heer 1863: 1049; Pl. 55, Figs 1–3)

Trematosphaerites lignitum (Heer) Beck (Beck 1882: 752; Pl. 31, Fig. 1).

Material. Gozdnica-Stanisław No. 83/287: 7 perithecia.

Family: **Microthyriaceae** gen.

Material. Gozdnica-Stanisław No. 83/271: 1 specimen.

Fungi gen. div.

Material. Gozdnica No. 83/45: 8 specimens; Gozdnica-Stanisław No. 83/195: 5 specimens.

Pteridophyta

Family: **Azollaceae**

Azolla filiculoides Lamarck fossilis

Azolla filiculoides Lam. (Lorié 1905: 30)
Azolla filiculoides Lam. (Florschütz 1938: 934; Pl. 19, Figs 1 & 2)
Azolla interglacialica Nikitin (Nikitin 1938: 151; Figs 1–6)

Material. Gozdnica No. 83/31: 1 megaspore.

Azolla tomentosa Nikitin

Azolla tomentosa Nikitin (Nikitin 1948: 1103)
Azolla tomentosa Nikitin (Dorofeev 1955: 118; Pl. 1, Figs 4–9)

Material. Gozdnica-Stanisław No. 83/241: 3 megaspores and some massulae.

Family: **Selaginellaceae**

Selaginella pliocenica Dorofeev

Selaginella pliocenica Dorof. (Dorofeev 1957: 489; Fig. 1)

Material. Gozdnica-Stanisław No. 83/286: 1 megaspore.

Coniferae

Family: **Pinaceae**

Pinus (*Pinus*) cf. *brevis* Ludwig

(Pl. 1, *1–7*; Pl. 11, 2)

Pinus brevis Ludwig (Ludwig 1857: 89; Pl. 19, Fig. 1)
Pinus brevis Ludwig (Mai 1973: 93; Pl. 1, Figs 8–10; Fig. 1)

Cone scale (Pl. 1, *4*) small, 3.5 mm wide and 4.5 mm long, apophysis narrow rhomboidal, slightly vaulted, with a transversal furrow, in which the small umbo is sunken.

Seeds (Pl. 1, *1–3*) ovoid, 2–2.5 mm wide and 3.5–4 mm long, sharply pointed.

Leaf fascicles (Pl. 1, *6 & 7*) joining the fragments of two needle-leaves, half-circular in cross section, about 1.5 mm across. The sheath persistent, wrinkeled across, attaining 5 mm in length. Leaves finely serrate on edges, amphistomatic, with 2–3 adaxial and 6–10 abaxial stomatal rows. Monocyclic stomata (Pl. 1, *5*) with deeply sunken guard cells, partly overarched by 2 polar and 4–6 lateral subsidiary cells, the former elongated, mostly shared by two neighbouring stomata, the latter small, isometric. The subsidiary cells bear slight proximal papillae which border the polygonal and slightly elongated stomatal pit.

Material. Gozdnica No. 83/313: 3 needles; Gozdnica-Stanisław No. 83/101, 152, 155–1, 155–2, 165, 171, 172, 275: 1 cone scale, 8 leaf fasciles, 6 needles, 32 seeds.

There is insufficient material for precise determination. The cone scales with sunken umbos and pointed seeds are typical of the *Pinus brevis* complex (European Late Miocene to Pliocene), which seems to be related to the extant *P. mugo* Turra (Mai 1986). The associated leaf remains show very similar patterns of stomatal complexes to *P. mugo* but the number of adaxial stomatal rows is much lower.

Pinus (*Pinus*) cf. *spinosa* Herbst

(Pl. 1, *8–13*)

Pinus spinosa Herbst (Herbst 1844: 567–568)
Pinus spinosa Herbst (Mai 1965b: 40–43; Pl. 3, Figs 2–6)

The leaf fascicles (Pl. 1, *10 & 11*) join the fragments of three needles, flat compressed, slightly triangular in cross section, serrate at margins. The sheath persistent, incompletely preserved, more than 5 mm long. Stomata in rows, the number of rows uncertain. Guard cells sunken, surrounded usually by 6 subsidiary cells, 4 lateral and 2 polar, without prominent papillae, stomatal pit (Pl. 1, *13*) polygonal, isometric, *ca* 25–30 µm across. One small fragment of a juvenile female cone (Pl.

1, *12*) showing rhomboid, slightly vaulted apophyses with transversal keel and sharp mucro (the outline of umbo not discernible). Resin droplet adhering to the cone surface. Seeds (Pl. 1, *8, 9*) oval (triangular), larger (3 x 4 mm).

Material. Gozdnica No. 83/12: 1 cone fragment, 3 needles; Gozdnica-Stanisław No. 83/166–168, 170, 173, 277: 4 cone fragments, 4 leaf fascicles with needle fragments, 1 needle, 1 needle fragment destroyed by maceration, 2 seeds.

The material is insufficient for exact determination, but best comparable to *Pinus spinosa* Herbst as described from the type locality of Kranichfeld (Mai 1965b, 1986). The species occurs in the Late Neogene of Central Europe.

Pinus (*Strobus*) *leitzii* Kirchh.

(Pl. 2, *1–9*, Pl. 11, *2*)

Pinus leitzii Kirchheimer (Kirchheimer 1936: 215; Pl. 13, Fig. 1a–d)

Pinus leitzii Kirchheimer (Stachurska *et al.* 1971: 367; Pl. 12, Figs 1–11)

Brachyblasts (Pl. 2, *1 & 3*) cylindrical, about 2 mm long and 1.5 mm wide, mostly devoid of sheath, usually bearing basal parts of 5 needle leaves. The leaves triangular in cross section, less than 1 mm wide, finely serrate (Pl. 2, *5*) on the margin (the teeth are rare or lacking on the keel). The leaves are epistomatic, the monocyclic stomata are arranged in separate longitudinal rows per 1–3 on either side of the adaxial keel (Pl. 2, *4*). On the inner structure, two resin ducts running parallel to the margins are visible in some specimens.

Male cones (Pl. 2, *8 & 9*) are only up to 2 mm wide and about 3 mm long, ovate, non-elongated, with broadly triangular sterile bracts at the base and helically disposed stamens. The maceration of the stamens has yielded pollen of the *Pinus haploxylon* type sensu Rudolph (Pl. 2, *6 & 7*; Pl. 3).

Material. Gozdnica No. 83/1, 8–11, 300, 307, 308, 312, 316, 317: 17 seeds, 270 male cones with pollen *in situ*, 245 brachyblasts, 182 needles; Gozdnica-Stanisław No. 83/137, 138, 200–202, 276: 11 seeds, 113 male cones, 69 brachyblasts, 175 needles.

In view of the occurrence of characteristic cones of *Pinus leitzii* Kirchh. at Gozdnica (Stachurska *et al.* 1971), we are fairly confident that the other associated organs of the *Pinus* subgen. *Strobus* type belong to the same species. Considering of the anatomy of the needles, the material from Gozdnica matches well with the needle leaves described under the same name from the Pliocene Vildštejn Complex, West Bohemia (Bůžek *et al.* 1985).

Tsuga (sect. *Tsuga*) sp. (Pl. 2, *11 & 12*)

Leaves (Pl. 2, *11*) lineal, shortly petiolate, 1–1.5 mm wide, hypostomatic. Petiole thin, bent. Cuticles of either leaf side very delicate, cells in non-stomatal areas linear, parallel-sided, about 15–18 µm wide and up to 150 µm long, straight-walled. Two stomatal bands on either side of the midrib including about 5 rows of widely spaced stomata (Pl. 2, *12*). Stomata incompletely bicyclic, longitudinally arranged, stomatal pit very thinly cutinized, quadrangular-elongate 8 x 20 x 22 µm in size, surrounded by two lateral half moon-shaped and two polar elongate subsidiary cells (the latter usually shared by two adjacent stomata) and 2–3 encircling cells hardly differing from the ordinary ones.

Material. Gozdnica-Stanisław No. 83/156, 162: 3 needle fragments.

The fragmentary nature of the remains prevent precise determination, however, the stomata and petiolate base reliably indicate the generic determination.

? Pinaceae gen. et sp. indet. (Pl. 2, *10*)

Brachyblasts (Pl. 2, *10*) are broadly oval, up to 7 mm long and 5 mm wide, covered with crowded triangular, mucronate bracts showing in maceration prosenchymatous tissue like bracts of the male cones in *Pinus leitzii* Kirchh. (see above). No remains of stamens have been ascertained between bracts.

Material. Gozdnica No. 83/97, 97–1, 97–2: 12 buds (brachyblasts with sterile bracts).

The available features do not allow a more accurate determination, but the remains most probably correspond to sterile brachyblasts of a pine situated in the terminal parts of younger twigs, according to the associated foliage remains.

Family: **Taxodiaceae**

Sequoia abietina (Brongn.) Knobloch

(Pl. 4, *1–10*, Pl. 5)

Phyllites abietina Brongniart (Cuvier 1822: 360; Pl. 11, Fig. 14)
Sequoia abietina (Brongn.) Knobloch (Knobloch 1964: 601)
Sequoia langsdorfii (Brongn.) Heer (Stachurska *et al.* 1971: 368; Pl. 13, Figs 1–10)

Foliage trimorphous. 'Taxodioid' twigs (Pl. 4, *1 & 2*) bear helically attached two ranked needle leaves, flat, up to 25 mm long and nearly 3 mm wide, adaxially with a longitudinal furrow, abaxially with slightly swollen midrib and margins, at the base twisted, markedly decurrent. Leaves are amphistomatic, on adaxial side with two incomplete rows of longitudinal stomata, not reaching the tip (Pl. 5, *3*), on abaxial side with two stomatal bands consisting of up to 18 rows (Pl. 5, *4*). Non-stomatal areas consist of usually very narrow and long parallel-sided cells with acute ends. Stomata are amphicyclic, mostly longitudinally oriented, cuticle of stomatal apparatus slightly darker than in ordinary cells. Stomatal apparatus includes usually two cycles of subsidiary cells, the inner ones usually narrower bordering thickenned margin of stomatal pit. 'Cryptomerioid' twigs (Pl. 4, *4*) bear also helical needle-like leaves, but quadrangular (or elliptic) in cross section, with two bands of thickly set transversaly or obliquely oriented stomata on adaxial side and with rare stomata on abaxial side. 'Cupressoid' twigs (Pl. 4, *3 & 8*) have triangular flat scale-leaves, that are usually helical but at the end of the twig nearly decussate. The leaves bear adaxially (Pl. 5, *1*) two triangular bands of irregularly arranged stomata, abaxially (Pl. 5, *2*) without or with one or two stomata. The male cones (Pl. 4, *7*) are terminal, rather inconspicuous, on cupressoid twigs. When macerated they yielded pollen *in situ* of the *Sequoiapollenites polymorphosus* Thierg. type (Pl. 4, *5 & 6*). Fragments of immature female cones with central mucro, adaxially with several ovules. Detached seeds (Pl. 4, *9 & 10*) of the type common with *Sequoia sempervirens* Endl.

Material. Gozdnica No. 83/4, 5, 13–18, 23, 75, 301, 306, 309, 315: 13 fragments of cones, 176 seeds, 753 leaf and twig fragments, 210 leaves, 8 cone scales; Gozdnica-Stanisław No. 83/98, 105, 111, 116, 122, 123, 136, 139, 141, 142, 144–147, 149, 153, 154, 159, 209–214: 253 seeds, 200 twig fragements, 172 leaves, 2 scales, 2 cone scales.

Unusually long-leaved twigs, which have been encountered as compressions at Gozdnica, correspond in all respects with *Sequoia sempervirens*-like foliage known from several localities of European Neogene. The same form of foliage is known particularly from Salzhausen, for which the name *Sequoia langsdorfii* (Brongn.) Heer has been introduced. For reasons of priority, however, the correct name of *Sequoia abietina* (Brongn.) Knobloch is preferable (Kvaček 1976).

The remains of this species are mostly connected with lignites and drifted deposits, particularly abundant in middle parts of Neogene, e.g. in the Rheinland (Kilpper 1968; Van der Burgh 1987).

Taxodium dubium (Sternb.) Heer

(Pl. 4, *11–13*, Pl. 6)

Phyllites dubius Sternb. (Sternberg 1823: 37; Pl. 36, Fig. 3)
Taxodium dubium (Sternb.) Heer (Heer 1855: 49–50; Pl. 17, Figs 5–15)

Fragments of twigs bear basal parts of two ranked, helically attached 'taxodioid' flat leaves with longly decurrent bases (Pl. 4, *11*). Detached leaves are acicular, up to 1 mm wide and not more than 10 mm long. Leaves are partly amphistomatic, on abaxial side (Pl. 6, *1–2a*) with two bands, each consisting of up to 8 irregular rows of amphicyclic stomata, usually obliquely or transversally oriented, characteristic by large, slightly cutinized subsidiary cells. Adaxial stomatal bands less regular, with 0–3, partly incomplete rows of stomata like those on abaxial side. Ordinary epidermal cells in non-stomatal areas are parallel-sided, quadrangular, less elongated than in *Sequoia abietina* (Brongn.) Knobloch.

Seed of the type common with *Taxodium distichum* Rich.

Material. Gozdnica No. 83/54–56: 1 seed, 13 leafy twigs, 41 needles; Gozdnica-Stanisław No. 83/140, 215: 18 leafy twigs, 63 needles.

The fragments of twigs are sometimes difficult to differentiate from *Sequoia* Endl. on the basis of morphology. The orientation of stomata and size of subsidiary cells afford reliable evidence to recognize *Taxodium* Rich. The available material differs in no way from the topotypical specimens of *Taxodium dubium* (Sternberg) Heer from the environs of Bílina, North Bohemia.

Family: **Cupressaceae**

Tetraclinis salicornioides (Unger) Kvaček (Pl. 7, *1–9*)

Thuites salicornioides Unger (Unger 1841: 11; Pl. 2, Figs 1–4)
Tetraclinis articulata (Vahl.) Masters (Stachurska *et al.* 1971: 374)
Tetraclinis salicornioides (Unger) Kvaček (Kvaček 1989: 48; Fig. 1, Pl. 1, Fig. 11; Pl. 2, Figs 2–14; Pl. 3, Figs 3 & 4)

Several medial parts of twigs and some terminal parts (Pl. 7, *5 & 7*) consisting of two elliptical (to rounded) flattened leaf whorls (0.2–0.4 cm wide and 0.2–0.8 cm long), mostly completely fused. On some terminal parts the tips of the leaves are free. Adaxial cuticle with prominent papillae on ordinary cells (Pl. 7, *8 & 9*). Monocyclic stomata scattered in irregular longitudinal rows over the surface. The subsidiary cells form a thick cutin rim around the stomatal pit. Sunken guard cell pairs (*ca* 40 μm across) well visible. A small cone consisting of 4 slightly dimorphous scales (Pl. 7, *1–4*), broadly obovate, with small tips of the fused bract on the abaxial (dorsal) side, and more ovules on the adaxial side. The cone in juvenile stage attains hardly 2 mm in length.

Material. Gozdnica-Stanisław No. 83/143–2, 160, 169, 216: 2 cone scales, 40 parts of twigs.

Although the remains are fragmentary and detached, their assignement to *Tetraclinis salicornioides* (Unger) Kvaček can be guarranted. Like in many other localities from the European Tertiary, at Gozdnica detached twigs and cones occur simultaneously. In the material available only a juvenile cone is preserved, however, a cone scale was recorded as *Tetraclinis articulata* (Vahl.) Masters by Stachurska *et al.* (1971).

Cupressaceae gen. et sp. (Pl. 7, *10*)

The apical fragment of twig (Pl. 7, *10*) bears two decussate pairs of scale leaves, dorsiventrally flattened. The leaves are differentiated, as in some Cupressaceae, into marginal and facial ones. The marginal leaves are mucronate, the facial rounded, with a domed abaxial surface. No anatomical data have been obtained due to the uniqueness of the specimen.

Material. Gozdnica-Stanisław No. 83/143–1: 2 leaf whorls.

Morphological features suggest the affinity with *Chamaecyparis* Spach. or *Thuja* L. The fragment differs from similar material described as *Thuja* cf. *occidentalis* L. (Łańcucka-Środoniowa 1966) by its mucronate marginal leaves.

Angiospermae – Dicotyledones

Family: **Ceratophyllacaeae**

cf. *Ceratophyllum* sp. (Pl. 9, *8 & 9*)

Material. Gozdnica-Stanisław No. 83/251: fragment of 1 fruit.

Family: **Caryophyllaceae**

cf. *Stellaria* sp. (Pl. 9, *7*)

Material. Gozdnica-Stanisław No. 83/288a: 1 seed.

Family: **Chenopodiaceae**

Chenopodium album L. fossilis

Chenopodium album L. fossilis (C. & E. M. Reid 1907: 219; Pl. 14, Fig. 118)

Material. Gozdnica-Stanisław No. 83/252: 1 seed.

Family: **Polygonaceae**

Rumex sp.

Material. Gozdnica-Stanisław No. 83/282: 1 fruit.

Family: **Altingiaceae**

Liquidambar sp. (Pl. 9, *5 & 6*)

Seeds minute (1.2–1.4 x 0.75–1.0 mm), irregular in shape, sharp-edged, flattened and slightly wrinkled, brown. Hilum marked as elongated aperture. On the outer surface elongate cells of thick walls are visible.

Material. Gozdnica No. 83/49: 49–1, 4 seeds.

These remains are very similar to aborted seeds of the genus *Liquidambar* L. which were found together with ripe seeds. The ripe seeds differ from the aborted ones not only in their larger size but also in their more regular outline and fairly large wings. The aborted seeds of *Liquidambar* were reported from the Mio-Pliocene flora of Sośnica (Łańcucka-Środoniowa *et al.* 1981). They were described in detail from the Middle Miocene flora of Fasterholt (Friis 1985: 28; Pl. 3, Figs 4–6).

Family: **Fagaceae**

Fagus silesiaca Walther & Zastawniak var. ***gozdnicensis*** Zastawniak & Kvaček, *var. nov.* (Fig. 7; Pl. 8, *6*; Pl. 9, *3 & 4*; Pl. 11, *2–4*; Pl. 12, *1–4*)

Leaves narrow-ovate to oblong, base cuneate, cuneate-rounded or rounded, slightly assymetric, apex slightly attenuate. Leaf margin simple serrate. Venation pinnate, semicraspedodromous or pseudo-craspedodromous.

Holotypus: KRAM-P No. 83/99 & Pl. 9, *3*

Isotypus: KRAM-P No. 83/117 & PL. 9, *4*

Locus typicus: POLAND, LOWER SILESIA, Gozdnica

Stratum typicum: Gozdnica Series, Late Miocene

Derivatio nominis: From the name of locality.

Fig. 7. Leaf margin of *Fagus silesiaca* Walther & Zastawniak var. *gozdnicensis* Zastawniak & Kvaček, *var. nov.* from Gozdnica-Stanisław, holotype KRAM-P No. 83/99.

Morphology. Leaves preserved only in fragments. The original shape narrow-ovate to oblong, base cuneate, cuneate-rounded or rounded, frequently slightly asymmetric. Petiole *ca* 0.5 cm long. Leaves narrowed towards the apex, one specimen with a slightly attenuate apex. The length of leaves from 4.0 to slightly more than 8.0 cm, width 2.0–4.0 cm. Leaf margins simple serrate (Fig. 7). Teeth tiny, slightly recurvate upwards, blunt. Leaf margin between the neighbouring teeth straight or slightly convex. Venation pinnate, semicraspedodromous or pseudo-craspedodromous (see Hummel 1983, Fig. 11). Primary vein moderately thick, its course sinuous at the apical parts of leaves. Full number of secondary veins unknown, up to 10 pairs are discernible on more complete specimens. Secondary veins come from the primary vein alternately at spaces (4.5)5–8(9) mm, at an angle (35°)38°–42°(43°) in medial parts of leaves. Course of secondaries ± straight. Tertiary veins percurrent, quaternary veins orthogonal.

Anatomy. Epidermis of both leaf sides extremely thin cutinized. Adaxial epidermis (Pl. 12, *2*) compound of polygonal cells with undulate anticlines, 30–35 μm across, partly elongate over veins (up to 50 μm in length). Abaxial epidermis (Pl. 12, *3 & 4*) smooth (without papillae), bearing stomata in groups, rare bases of serial glandular trichomes (10–12 μm across), solitary or partly in pairs, and small tufts of simple unicellular trichomes (up to 300 μm long) in the axilles of secondary veins (Pl. 12, *1*). Ordinary cells polygonal, in part slightly elongated, *ca* 15 x 40 μm in size, with finely undulate anticlines. Stomatal type variable, mostly cyclocytic, or incompletely cyclocytic, occasionally also anomocytic. Guard cell pairs rounded to broadly elliptic (to transversally elliptic), 17–26 x 19–26 µm in size, in submacerated samples with T-pieces in poles, and short narrow spindle-like pore. Subsidiary cells mostly 4–6, either narrow surrounding the guard cells, partly larger, oriented radially, in some cases not differentiated from ordinary cells.

Material. Gozdnica-Stanisław No. 83/99–108, 110, 112–115, 117, 120, 121, 124, 126, 129, 133, 134 + twin impression 135, 136, 149–151: 59 compressions/impressions of leaf fragments.

Maceration by Schulze's solution did not yield useful preparations, however, and so only the procedure with hydrogene hyperoxide (Kvaček 1966) did allow for examination of the observations of the epidermal structure on submacerated samples. The epidermal characteristics largely correspond with those given by Hummel (1983) for *Fagus silesiaca* Walther & Zastawniak (as *F. attenuata* Goepp.) from Ruszów, and by Walther and Zastawniak (1991) from Sośnica, the only additions being irregularities in the cyclocytic type of stomata and in the trichome tufts in the axilles of secondaries.

The anatomical features of the described leaves correspond well to other records ascribed to *F. silesiaca* Walther & Zastawniak (= *F. attenuata* Goepp.), but the morphological features are slightly different – our leaves are slender, the secondaries are steeper, the venation is without exception semicraspedodromous or pseudo-craspedodromous, which is not the case with the Ruszów and Sośnica material. Therefore, the beech leaves found in Gozdnica have been identified as a variety of *Fagus silesiaca* Walther & Zastawniak (Walther & Zastawniak 1991: 156; Pl. 1, Figs 1 & 4–6). The abundant fossil fruits of *Fagus microcarpa* Miki *emend.* Uemura, occurring with these leaves and undoubtedly belonging to the same trees (see Pl. 9, *4*) prove that the beech trees in Gozdnica were different to beeches with the fruits of *Fagus decurrens* C. & E. M. Reid or *Fagus ferruginea* Ait. fossilis Nathorst and the leaves of *F. silesiaca* (= *F. attenuata*). It would be difficult to ascribe a new species to these remains as the anatomical structure is in complete accordance with the leaves of *F. silesiaca* Walther & Zastawniak, however, a few slight morphological and anatomical differences do exist.

The leaves of a recent *Fagus hayatae* Palibin *ex* Hayata (Pl. 13) are very similar to the fossil leaves described here.

Fagus microcarpa Miki *emend.* Uemura
(Figs 8–10; Pl. 8, *1–4*; Pl. 9, *1* & *2*)

Fagus microcarpa Miki (Miki 1933a: 8; Pl. 2, Fig. F; Fig. 3N)
Fagus microcarpa Miki (Miki 1933b: 621; Pl. 1, Fig. G; Fig. 1 L, M)
Fagus sp. (Stachurska *et al.* 1971: 369; Pl. 13, Figs 11–16)
Fagus microcarpa Miki *emend.* Uemura (Uemura 1980: 36; Figs 1–10 & 14–16)

Nuts small, trigonous, broad at the base, strongly winged on the edges, particularly in the upper part. The apex elongate pointed. Cupules pedunculate with four bracts. Bracts covered with densly spaced, fairly thin, pointed and divergent spines. Numerical values of measurements of nuts and cupule bracts elaborated by M. Białobrzeska (Cracow) are shown in Table 4 and Figs 8–10.

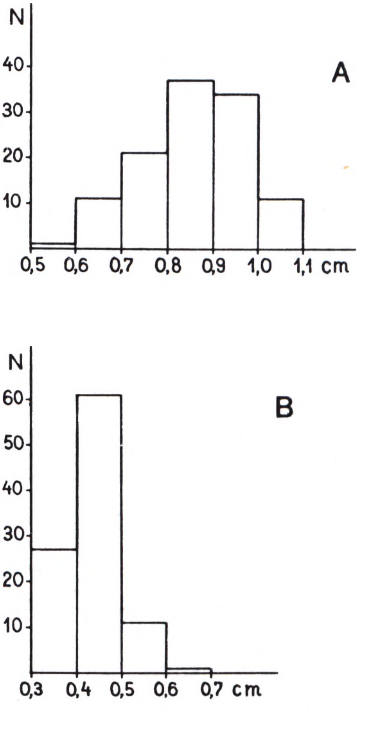

Fig. 8. Histograms of *Fagus microcarpa* Miki *emend.* Uemura nutlets length (A) and width (B) (after M. Białobrzeska, unpubl.).

Table 4. Biometrical analysis of *Fagus microcarpa* Miki *emend.* Uemura fruits from Gozdnica (after M. Białobrzeska, unpubl.). M – arithmetic mean, M_o – modal value, V – coeficent of variability, m – standard error.

Length of cupule valve				Width of cupule valve				Apical angle of cupule valve			
min. – max.	M_o	M ± m	V	min. – max.	M_o	M ± m	V	min. – max.	M_o	M ± m	V
0.60–1.15	0.8	0.86 ± 0.01	16.27	0.30–0.75	0.6	0.55 ± 0.008	14.54	46–125	85	75.10 ± 1.59	21.23
Basal angle of cupule valve				Ratio of length to width of cupule valve				Position of the broadest part of cupule valve in %% of its length			
min. – max.	M_o	M ± m	V	min. – max.	M_o	M ± m	V	min. – max.	M_o	M ± m	V
25–180	136	118.40 ± 3.49	29.54	1.00–2.57	1.6	1.65 ± 0.03	18.78	26.3–75.0	45	46.25 ± 0.92	20.00

Length of nutlet				Width of nutlet				Apical angle of nutlet			
min. – max.	M_o	M ± m	V	min. – max.	M_o	M ± m	V	min. – max.	M_o	M ± m	V
0.55–1.05	0.8	0.81 ± 0.01	12.34	0.30–0.60	0.45	0.41 ± 0.01	14.63	23–85	50	51.00 ± 1.45	28.52
Basal angle of nutlet				Ratio of length to width of nutlet				Position of the broadest part of nutlet in %% of its length			
min. – max.	M_o	M ± m	V	min. – max.	M_o	M ± m	V	min. – max.	M_o	M ± m	V
97–180	135	140.15 ± 1.83	13.05	1.54–2.85	2.00	2.04 ± 0.03	13.72	21.0–46.1	35	34.50 ± 0.40	11.73

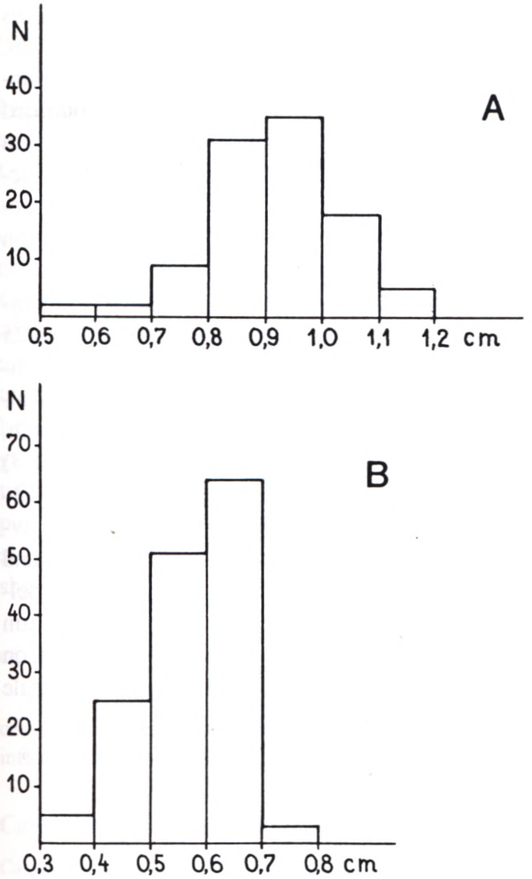

Fig. 9. Histograms of *Fagus microcarpa* Miki *emend.* Uemura cupule valves length (A) and width (B) (after M. Białobrzeska, unpubl.).

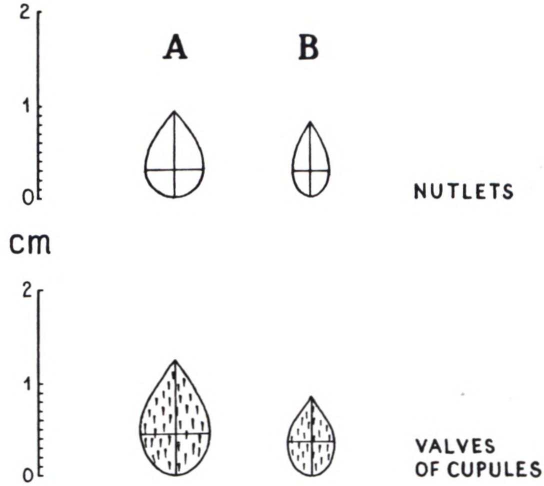

Fig. 10. The nuts and cupule valves of *Fagus* aff. *grandifolia* Ehrh. from the Miocene of Koniówka (A – after Białobrzeska & Truchanowiczówna 1983) and *Fagus microcarpa* Miki *emend.* Uemura from Gozdnica (B – after M. Białobrzeska, unpubl.), drawn on the basis of the arithmetic means of the characters.

Material. Gozdnica No. 83/6, 359–361: 157 nutlets, 164 cupules and their fragments; Gozdnica-Stanisław No. 83/98, 106–110, 114, 117, 125, 131, 188–193, 264–267, 362–365: 323 nutlets, 662 cupules and their fragments.

In earlier investigations (Stachurska *et al.* 1971) it was stated that the beech fruits from Gozdnica, which are very abundant in this flora, differ from other fossil species of this genus present in other localities by having smaller sized cupules and nuts. It was possible to apply biometric investigations to the beech fruits due to the abundance of the fossil material. The figures given in Table 4 and Figs 8 and 9 detail all the quantitative morphological features of beech from Gozdnica. If we compare these data with the results of the biometric analysis of fruits of *Fagus* aff. *grandifolia* Ehrh. from the Miocene of Koniówka (Białobrzeska & Truchanowiczówna 1983, Table 1 & 2), we can see that there are indeed differences in size: the fruits of Gozdnica are smaller and distinctly narrower (Fig. 10). The other beech species from the Neogene of Europe, such as *F. decurrens* C. & E. M. Reid, *F. pliocenica* Geyler & Kinkelin and *F. ferruginea* Ait. fossilis Nathorst also have considerably bigger fruits.

The beech remains at Gozdnica most closely resemble *F. microcarpa* described by Miki (1933a, b) from the Pleistocene of Japan. This species has also been noted from other Pliocene and Pleistocene sites in Japan and are exactly described and characterized by Uemura (1980).

F. microcarpa Miki *emend.* Uemura is most closely related to the recent *F. hayatae* Palib. *ex* Hayata (Pl. 13) growing in Taiwan and Prov. Hubei (China) and also to *F. pashanica* C. C. Yang[1] (Szechuan, China). Some morphological

[1] *Fagus pashanica* C. C. Yang is now considered by the author of the species as a synonim for *F. hayatae* Palibin apud Hayata (Li Hao-min, the letter from July 12th, 1989).

features of the cupules and nuts of *F. microcarpa* are similar to another modern species from Japan, *F. crenata* Bl., although this has considerably bigger fruits (Uemura 1980; see also Białobrzeska & Truchanowiczówna 1983, Fig. 8).

The species *F. microcarpa* Miki *emend.* Uemura has not hitherto been described from the European fossil flora. It is also worthy of note, that Łańcucka-Środoniowa in 1992 found a small beech cupule, very similar to *F. microcarpa* Miki *emend.* Uemura, in the Pannonian deposits at Bełchatów (Profile VI b; KRAM-P No. 191/488).

Fagus sp. (Pl. 8, *5*)

Fragmentary cymose inflorescences with obliterated surface features, *ca* 5 mm long and 2–3 mm wide. Two specimens yielded pollen of the *Faguspollenites verus* Raatz type (Pl. 10). The size varies in the unmacerated samples lies in the range 34–40 µm (polar axis) and 32–37 µm (equatorial axis). The exine consists of rod-like elements, partly fused, giving rise to a clustering pattern.

Material. Gozdnica-Stanisław No. 83/194: several fragmentary inflorescences, 12 buds.

The assignment to *Fagus* is not absolutely certain on the basis of inflorescences morphological features. In view of the identification of the *in situ* pollen and the common occurrence of *Fagus* remains at Gozdnica, the above determination is highly probable. The pollen *in situ* corresponds to the forms of *Faguspollenites verus* found dispersed in the Late Miocene of the Rheinland (see Gortemaker 1986).

Family: **Betulaceae**

Betula longisquamosa Mädler (Pl. 15, *1 & 2*)

Betula longisquamosa Mädler (Mädler 1939: 73; Pl. 6, Figs 21 & 22; Pl. 7, Figs 13 & 14)

Material. Gozdnica No. 83/290: 4 nuts; Gozdnica-Stanisław No. 83/174, 175, 242: 141 nuts.

Betula subpubescens Goeppert (Fig. 11; Pl. 11, *1 & 1a*; Pl. 14, *1–4*)

Betula subpubescens Goeppert (Goeppert 1855: 11; Pl. 3, Fig. 9)

Morphology. Only small fragments of leaves have been preserved. Width of one leaf 2.3 cm. Margins of the leaves double serrate. Teeth triangular, relatively wide at the base, with rounded tips (Fig. 11). 1–2 slightly smaller additional teeth between somewhat coarser ones at the ends of secondary veins. Venation craspedodromous. Secondary veins alternate, coming from the main vein at an angle 42° in medial parts of leaves.

Anatomy. Adaxial cuticle fragmentary, composed of rectangular, ± straight-walled cells 15–25 µm. Abaxial cuticle (Pl. 14) medium thick, ordinary epidermal cells 15–30 µm across, with almost straight to slightly wavy walls, smooth, around stomata thinner. Stomata (Pl. 14, *2 & 3*) anomocytic, guard cell pairs elliptic 14–37 x 12–20 µm in size, with broadly spindle-like outer cavity attaining more than half of stomatal length, and a narrow and long aperture. Solitary bases of peltate glandular trichome (Pl. 14, *4*) 28–32 µm across, composed of 4 to 9 faintly visible cells, on veins, occasionally with preserved distal scale (about 100 µm across).

Fig. 11. Leaf margin of *Betula subpubescens* Goepp. from Gozdnica-Stanisław, KRAM-P No. 83/99.

Material. Gozdnica-Stanisław No. 83/99, 111: 2 fragments of leaf compressions.

In spite of the fragmentary morphology, the leaf compressions compare well in their dense craspedodromous secondaries, straight midrib and fine sharp marginal teeth with *Betula subpubescens* Goeppert, a type common in the type locality of Sośnica. The cuticle structure eliminates an assignment to other Betulaceae, particularly to *Carpinus* L. (no polycellular trichome bases) or *Alnus* Miller (mostly 4–5 cells per trichome base) and supports the affinity to *Betula* L. (stomatal type, wide variation in size of stomata, polycellular bases). Most of the recent species differ by the greater size of their stomata. The fragmentary nature of the cuticles prevent us from tracing the presence, or extent of pubescence, which would aid a better understanding of the recent relationship.

cf. *Betula* sp. (Pl. 15, *3*)

Material. Gozdnica No. 83/289: 1 male inflorescences; Gozdnica-Stanisław No. 83/176: 18 fragments of inflorescences.

Carpinus moldavica Negru (Pl. 15, *4–7*)

Carpinus moldavica Negru (Negru 1982: 168; Pl. 171, Figs 11 & 12)

Nuts 3.0–5.2 x 1.8–3.4 mm, rounded at the base, narrowed at the apical part. The greatest width below half of the nut length. Vascular bundles are fairly thick, 6 on each side. Nuts without ribs.

Material. Gozdnica No. 83/38: 1 nut; Gozdnica-Stanisław No. 83/179, 249, 250: 6 nuts.

The remains are similar to the nuts of the contemporary North American *Carpinus caroliniana* Walther, which differ from those of *C. betulus* L. in that its widest part is situated lower, it has a sharper apex and it lack ribs. In Negru's (1982) opinion the species *Carpinus moldavica* Negru, described from the Miocene of Moldavia, is similar to *C. caroliniana* Walther, although it has some morphological and anatomical features in common with *C. tschonoskii* Maxim. and *C. betulus* L.

The fruit bracts of *C. caroliniana* Walther type have been reported from the Tertiary of Europe (Berger 1953; Jentys-Szaferowa 1958; Givulescu & Ghiurca 1969; Givulescu & Olos 1973, and others).

Ostrya szaferi Mai (Pl. 15, *8 & 9*)

Ostrya szaferi Mai (Mai & Walther 1988: 137; Pl. 25, Figs 23 & 24)

Material. Gozdnica-Stanisław No. 83/273: 2 nuts.

Family: **Myricaceae**

Myrica ceriferiformis Kownas (Pl. 15, *13 & 14*)

Myrica ceriferiformis Kownas (Kownas 1956: 459; Figs 8a & b)

Material. Gozdnica-Stanisław No. 83/199, 272: 17 fruits.

Family: **Theaceae**

Eurya stigmosa (Ludwig) Mai (Pl. 15, *10–12*)

Potamogeton stigmosus Ludwig (Ludwig 1860: 60; Pl. 8, Fig. 13)
Eurya stigmosa (Ludwig) Mai (Mai 1960: 79; Pl. 4, Figs 8–17; Fig. 4)
Eurya stigmosa (Ludw.) Mai (Stachurska *et al.* 1971: 371; Pl. 14, Fig. 14)

Material. Gozdnica-Stanisław No. 83/263: 2 seeds.

'Viburnum ' atlanticum Ettingshausen (Pl. 17, *1–4*)

Viburnum atlanticum Ett. (Ettingshausen 1868: 209; Pl. 36, Fig. 2)
'Viburnum' atlanticum Ett. (Bůžek 1971: 96; Pl. 49, Figs 1–12; Pl. 51, Fig. 13)

One fragment of a marginal tooth with a gland on the tip, barely 2 mm in size. Adaxial cuticle (Pl. 17, *1*) medium thick, smooth, hairless and without stomata, epidermal cells polygonal, 10–20 µm across, with nearly straight to slightly finely wavy anticlines. Abaxial cuticle (Pl. 17, *2–4*) of the same thickness, partly with striation around stomata. Ordinary epidermal cells polygonal, 12–15 µm across with slightly bent to finely wavy anticlines. Stomata cyclocytic (Pl. 17, *3 & 4*), guard cell pairs roundish to broadly elliptic, 18–30 µm long, with distinct concentric lamella, partly preserved as striae, and a small rounded outer cavity formed by thick ledges, pore small, elliptic, susbsidiary cells 4–6 (8), only partly differing by narrower shape and darker staining from the ordinary cells. Pubescence not observed.

Material. Gozdnica-Stanisław No. 83/163: 1 leaf fragment.

The same cuticular structure is known (Z. Kvaček's own observation) from leaves occurring in the Early Miocene of North Bohemia and identified as *'Viburnum' atlanticum* Ett. (see Bůžek 1971). The glandular teeth and the type of stomata suggest a relationship to Theaceae (*Eurya* Thunberg). In any case, the leaves were probably evergreen.

Family: **Symplocaceae**

Symplocos lignitarum (Quenstedt) Kirchheimer

Carpolithus lignitarum Quenstedt (Quenstedt 1867: 914; Pl. 86, Fig. 35, 41)
Symplocos lignitarum (Quenst.) Kirchh. (Kirchheimer 1949: 14; Pl. 1, Fig. 4, Pl. 2, Fig. 15)
Symplocos lignitarum (Quenst.) Kirchh. (Stachurska *et al.* 1971: 373; Pl. 13, Figs 19–22)

Material. Gozdnica-Stanisław No. 83/208: 1 fruit.

Family: **Guttiferae**

Hypericum sp. 1 (Pl. 16, *1* & *2*)

Material. Gozdnica No. 83/3: 19 seeds; Gozdnica-Stanisław No. 83/196: 1 seed.

Hypericum sp. 2 (Pl. 16, *3*)

Material. Gozdnica No. 83/295: 1 seed.

Hypericum sp. 3 (Pl. 16, *4* & *5*)

Material. Gozdnica No. 83/198: 34 seeds; Gozdnica-Stanisław No. 83/196, 268: 39 seeds.

Family: **Clethraceae**

Clethra friisii **Łańcucka-Środoniowa**, *sp. nov.* (Pl. 16, *6* & *7*)

Seeds 0.7–1.05 x 0.6–0.75 mm, elliptic or irregular in outline, dorso-ventrally flattened, with an uneven margin. The testa surface has large, shallow cells forming a distinct reticulum. On the dorsal side the cells are isodiametric, irregularly arranged. On the ventral side the elongated cells are arranged in longitudinal rows radiating from the chalaza which is marked as a circular aperture. Elongated marginal cells are bigger and at some points they form low and membraneous wings with even edges.

Holotypus: KRAM-P, No. 83/43, Pl. 16, *6*

Locus typicus: POLAND, LOWER SILESIA, Gozdnica

Stratum typicum: Gozdnica Series, Late Miocene

Derivatio nominis: In honour of Professor Dr. Else Marie Friis (Stockholm).

Material. Gozdnica No. 83/43: 3 seeds.

The features of the fossils clearly indicate a relationship to the extant seeds of *Clethra* L. and bear the greatest resemblance to seeds of the North American species *C. alnifolia* L. They differ from the seeds of *C. cimbrica* Friis described from the Miocene flora of Fasterholt (Friis 1985: 43; Pl. 9, Fig. 11; Pl. 10, Figs 1–4) by their smaller size and non-serrate, unwinged margin. Like Fasterholt, Gozdnica is a site with well documented macroscopic remains of the genus *Clethra*. Fossil leaves, fruits and seeds ascribed to the genus *Clethra* L. and reported hitherto from several European Tertiary floras, contain no features of this genus (Friis 1985). In several profiles from Tertiary deposits, as well as in Gozdnica (see Table 1 & 2), pollen grains determined as Cyrillaceae-Clethraceae occur. The recovery of well preserved seeds from the Miocene floras of Denmark and Poland confirms the presence of the genus *Clethra* in the Tertiary of Europe.

The recent genus *Clethra* L., monotypic in the family Clethraceae, includes almost 64 species of evergreen or deciduous shrubs or trees with a tropical and subtropical distribution. Most species grow in tropical America and Asia. Two species occur in temperate North America (Friis 1985).

Family: **Ericaceae**

Andromeda carpatica Łańcucka-Środoniowa (Pl. 16, *10*)

Andromeda carpatica Łańcucka-Środoniowa (Łańcucka-Środoniowa 1979: 67; Pl. 11, Fig. 11; Pl. 12, Figs 1–6)

Seed 1.8 x 1.27 mm, ovate, biconvex, with incurvations in lateral sides, due to compression. Hilum fairly large, oblong-oval, is situated asymmetrically at seed circumference. Testa thick, surface smooth, lustrous, with minute polygonal cells.

Material. Gozdnica No. 83/27: 1 seed.

In their size and shape, the seeds of this species most resemble those of *Andromeda brunnea* Dorof. from the Oligocene of West Siberia (Dorofeev 1963) but differ from them in some of the details of the outer structure of the testa. The species has been found in a few Neogene floras from Poland: the Nowy Sącz Basin, Domański Wierch, Koniówka, Czarny Dunajec (Łańcucka-Środoniowa 1979).

Andromeda nigra Dorofeev (Pl. 16, *8 & 9*)

Andromeda nigra Dorofeev (Dorofeev 1963: 253; Pl. 45, Figs 2–12)

Seeds 0.80–0.95 x 0.52–0.70 mm, oval or almost globular, biconvex, thick, sometimes folded due to fossilization (compression). The hilum oblong-oval, situated on the circumfenerce in a small oblique depression. Testa thick, its surface relatively smooth, lustrous, covered with small, circular and polygonal cells.

Material. Gozdnica No. 83/26, 26a: 8 seeds.

The seeds of this species are closely related to the recent *Andromeda polifolia* L., but differ in their smaller size and more conspicuous cells on the testa surface (Dorofeev 1963).

This is a new species for the Tertiary of Poland.

cf. *Enkianthus* sp. (Pl. 16, *13*)

The fruit is five-loculed capsule, elliptical in outline, measuring 3.7 x 3.0 mm. The capsule is laterally compressed, open at the top. Seeds are not preserved. The fruit walls are thick; isodiametric cells are arranged in longitudinal rows on the surface. The fruit bears a persistent calyx with five sepals strongly narrowed at the apex and almost reaching half of the capsule length. Sepal surface covered with minute, isodiametric cells. Thick and woody peduncle is preserved.

Material. Gozdnica No. 83/47: 1 fruit.

The fossil fruit shows similarity to the fruits of the extant genus *Enkianthus* Lour. and, for example, to the East Asian species *E. complanatus* Nakai (Pl. 16, *14*). This genus, in the fossil state, was first reported from the Miocene flora of Fasterholt (? *Enkianthus* sp., see Friis 1985), where one fruit with its calyx but without sepals and one seed inside the fruit were found. Those remains were compared with the modern *E. subsessilis* (Miq.) Makino from East Asia, however, the seeds have a slightly different structure.

The contemporary genus includes 10 extant species of deciduous or evergreen shrubs which existed the area of East Asia stretching from Japan to the Himalayas (Krüssmann 1977).

cf. *Lyonia* sp. (Pl. 16, *11 & 12*)

Seeds 1.5 x 0.27 mm, elongated, almost narrow oblong, sicle-curved at one end. Elongated cells arranged in longitudinal rows are seen on the testa surface. The anticlinal cell walls are thin and finely pitted.

Material. Gozdnica No. 83/74: 2 seeds.

Capsules, five-loculed, subglobose and containing several elongated seeds in each locule, were found in the Middle Miocene flora of Fasterholt (Friis 1985) and described as *Lyonia danica* Friis. The abundant and well preserved fossil fruits show a great similarity to fruits of the North American species *L. ligustrina* (L.) DC.

The contemporary genus *Lyonia* Nutt. includes about 35 species of shrubs occurring in North America and West India and 5 species in East Asia.

Vaccinium minutulum Łańcucka-Środoniowa (Pl. 16, *17 & 18*)

Vaccinium minutulum Łańcucka-Środoniowa (Łańcucka-Śodoniowa 1979: 66; Pl. 11, Figs 12 & 13)

Material. Gozdnica No. 83/299: 3 seeds.

Vaccinioides lusatica (Litke) Kvaček & Walther (Pl. 19, *1–6*)

Laurophyllum lusaticum Litke (Litke 1968: 177; Pl. 37, Figs 1 & 3; Figs 19–22)

Vaccinioides lusatica (Litke) Kvaček & Walther (Kvaček & Walther 1990: 581; Pl. 1, Figs 1–4; Pl. 2 & 3)

Leaf apex acuminate, blunt, entire margined, 8 x 12 mm in size. Venation not preserved except stout midrib, prominent abaxially. Texture coriaceous (leaf evergreen). Adaxial epidermis (Pl. 19, *3*) hairless, without stomata, made of polygonal cells with slightly bent anticlinal walls, about 25–30 µm across. Abaxial epidermis (Pl. 19, *5 & 6*) bearing paracytic stomata tending to form groups with parallel axes. Ordinary epidermal cells 30–45 µm across with bent zick-zack anticlinal walls. Pairs of guard cells elliptic with less distinct periphery, 14–16 x 20–28 µm in size; pore small, narrow, elliptic, polar T-pieces and broad continuous outer stomatal ledges. Subsidiary cells large, butterfly-like. Rare indistinct hair bases 10 x 15 µm across (Pl. 19, *4*).

Material. Gozdnica-Stanisław No. 83/321, 322: isolated leaf fragment.

The absence of secretory mesophyll elements and no sunken guard cells exclude an affinity to Lauraceae. Among the angiosperms with paracytic stomata the best match was found to be among the Ericaceae and namely in the subfam. Vaccinioideae Endl. Although the characteristic multicellular glandular hairs occurring in many Ericaceae have not been found, the same type of stomata with T-pieces and broad stomatal ledges are typically developed in *Vaccinium* L., *Agapetes* D. Don or *Gaylussacia* Kunth. (see Kvaček & Walther 1990). This is a new species for the Tertiary of Poland.

Family: **Cyrillaceae**

cf. ***Pirocarpella aquisgranensis*** Mai

(Pl. 16, *19–21*; Pl. 18, *1 & 2*)

Pirocarpella aquisgranensis Mai (Mai & Walther 1985: 88; Pl. 23, Figs 23–28)

The capsules are pear-shaped, 4 or 5-loculed, angular, in some places their splitting along locules is visible. At the base there is a circular disc with partly preserved calyx lobes. Style is thickened, single, non-branching. Capsule diameter (without disc and style) is 1.5–2.7 mm. The outer surface of fruits is wrinkled, with furrows and ribs.

Material. Gozdnica-Stanisław No. 83/187, 261, 262: 20 fruits.

The extinct genus was placed by Mai (Mai & Walther 1985) among the family Cyrillaceae on the basis of the morphological structure of its fruits and seeds. Only one species *Pirocarpella aquisgranensis* Mai from the Late Eocene and Late Miocene floras of Europe is known.

The taxon has not hitherto been described from the fossil flora of Poland.

Family: **Urticaceae**

Boehmeria sibirica Dorofeev

Boehmeria sibirica Dorofeev (Dorofeev 1959: 128; Fig. 2 zh)

Material. Gozdnica-Stanisław No. 83/243: 1 fruit.

Family: **Droseraceae**

Aldrovanda praevesiculosa Kirchheimer

(Pl. 16, *15 & 16*)

Aldrovanda vesiculosa L. fossilis (Kirchheimer 1935b: 28; Figs 5–7)

Aldrovanda praevesiculosa Kirchh. (Krichheimer 1941: 309; Fig. 1)

Aldrovanda vesiculosa L. fossilis (Raniecka-Bobrowska 1959: 178; Figs 6 & 7)

Seeds 1.17–1.37 x 0.9–1.05 mm, oval in shape, with a poorly marked chalaza (a beak) and short neck on which a circular micropylar aperture is visible. The testa is thick, its inner layer formed by palisade cells. The seed surface is strongly lustrous.

Material. Gozdnica No. 83/25, 25a: 3 seeds and 5 fragments of seeds.

The genus *Aldrovanda* L. includes a single living species *A. vesiculosa* L., an aquatic plant distributed in shallow waters in tropical and subtropical regions. Eight fossil species have been described from different stages of the Tertiary, with the earliest record coming from the Late Eocene (Dorofeev 1968; Friis 1985; Mai 1985). On the basis of seed morphology, Dorofeev (1968) grouped the *Aldrovanda* species into three sections. *A. praevesiculosa* Kirchh. is known in Europe mainly from Miocene deposits and seldom from Pliocene ones. In Poland, it was described as *A. vesiculosa* L. foss. in the Late Miocene of Konin (Raniecka-Bobrowska 1959).

Family: **Rosaceae**

cf. *Alchemilla* sp.

Material. Gozdnica-Stanisław No. 83/240: 1 fruit.

Rubus microspermus C. & E. M. Reid (Pl. 18, *6 & 7*)

Rubus microspermus C. & E. M. Reid (C. & E. M. Reid 1910: 169; Pl. 15, Figs 13–17)

Material. Gozdnica-Stanisław No. 83/207, 279, 280: 9 fruits.

Rubus sp. (Pl. 18, *8*)

Material. Gozdnica-Stanisław No. 83/281: 1 fruit.

Family: **Melastomataceae**

Melastomites tertiaria Dorofeev (Pl. 18, *3–5*)

Melastomites tertiaria Dorofeev (Dorofeev 1960: 1432; Pl. 4, Figs 8–10)
Melastomites tertiaria Dorofeev (Dorofeev 1963: 228; Fig. 32-2)
cf. *Portulaca* sp. (Raniecka-Bobrowska 1959: 169; Pl. 16, Figs 11–14)

Seeds minute, 1.0–1.6 x 0.7–1.2 mm, with the base hook-like curved, oblique-ovate in outline, thick and somewhat flattened. The apex is oblique truncate, slightly concave and covered with a lid furnished with a blunt beak. The testa is thick, outer surface mat and brown with small polygonal cells. Round and flattened nodules are seen on the seeds circumference.

Material. Gozdnica No. 83/68: 26 seeds; Gozdnica-Stanisław No. 83/ 198: 19 seeds.

Similar seeds, very characteristic in structure, have been found in many genera of the Melastomataceae, such as *Rhexia* L., *Dissotis* Benth. *in* Hook., *Monochaetum* Naud. and it is difficult to refer these fossils to a modern genus (Dorofeev 1960). The family Melastomataceae includes tropical plants.

The species *Melastomites tertiaria* Dorofeev has been described from the Miocene of Byelorussia and West Siberia. It has also been recorded from the Miocene of Poland, namely at Konin (Raniecka-Bobrowska 1959, as cf. *Portulaca* sp.), Bełchatów (Stuchlik *et al.* 1990), Rypin and Orłowo (Łańcucka-Środoniowa 1980b, c). Seeds from Gozdnica and Konin, photographed using a scanning electron microscope, are presented by Collinson & Pingen (1992).

Family: **Lythraceae**

Microdiptera menzelii (E. M. Reid) Mai

Diclidocarya menzelii E. M. Reid (E. M. Reid 1927: 3; Pl. 580, Figs 1–7)
Microdiptera menzelii (E. M. Reid) Mai (Mai 1987: 113; Pl. 7, Figs 11–12)

Material. Gozdnica No. 83/41: 1 seed.

Family: **Onagraceae**

Ludwigia cf. ***corneri*** Friis (Pl. 18, *11 & 12*)

Ludwigia corneri Friis (Friis 1985: 59; Pl. 18, Figs 1–7)

Seeds ellipsoid elongate with very elongated and partly damaged raphe and mucronate micropyle. The seed wall is thick and transversally elongated cells, arranged in longitudinal rows can be seen on its surface. Length of seeds 0.7–0.9 x 0.44 mm.

Material. Gozdnica No. 83/296, 297: 4 seeds.

The fossil seeds from a number of species have been described: *Ludwigia palustris* (L.) Elliot foss. from the Late Miocene, Pliocene and Pleistocene (Mai & Walther 1988), *L. krauseli* Mai from the Oligocene of Haselbach (Mai & Walther 1978), and *L. collinsoniae* Friis and *L. corneri* Friis from the Miocene flora of Fasterholt (Friis 1985). The last species differs from *L. palustris* (L.) Elliot fossilis in its bigger size and different scuplture of testa.

The contemporary genus *Ludwigia* L. includes about 75 species of herbs and small shrubs and is widely distributed in wetland environments from temperate and tropical regions. Most species grow in tropical America, however, one species, *L. palustris* (L.) Elliot occurs in Europe.

This species has not, hitherto, been described from the fossil flora of Poland.

Ludwigia palustris (L.) Elliot fossilis
(Pl. 18, *9 & 10*)

Ludwigia palustris (L.) Elliot fossilis (Mai *et al.* 1963: 786; Pl. 4, Figs 14 & 15)

Material. Gozdnica No. 83/2: 55 seeds.

This species was reported from Tertiary of Poland as *Hypericum coriaceum* Nikitin.

Family: **Haloragaceae**

Proserpinaca brevicarpa Dorofeev
(Pl. 18, *13 & 14*)

Proserpinaca brevicarpa Dorofeev (Dorofeev 1976: 1037; Fig. 1: 1–4)

Fruits 1.5–1.7 x 1.3–1.5 mm (only 1 specimen somewhat bigger, 1.8 x 1.6 mm), short, broadest in the lower half on their length, somewhat narrowed at the apex, the base slightly concave, with or without short stalk. Ribs compressed and somewhat edged on the lateral walls and also at the base. Stout longitudinal veins form winged ribs. The outer surface of the fruits is uneven, thin and somewhat gibbous nerves can be seen.

Material. Gozdnica-Stanisław No. 83/206, 278: 8 fruits.

This characteristic species for Miocene floras (Dorofeev 1976; Friis 1985), has also been reported from the Oligocene of Middle Europe (Mai & Walther 1978). It differs from the other fossil species by its distinctly smaller size and different shape of the fruit base (Dorofeev 1976). Gozdnica is the first site for this species in the Tertiary of Poland.

Family: **Fabaceae**

Gleditsia knorrii (Heer) Gregor
(Pl. 18, *15 & 16*)

Podogonium knorrii Heer (Heer 1859: 114; Pl. 135, Fig. 21)
Gleditsia knorrii (Heer) Gregor (Gregor & Hantke 1980: 166; Pl. 11, Fig. 3)

Material. Gozdnica No. 83/293, 294: 3 fragments of pods.

Neither fruits nor seeds have been recorvered from the fossil floras of Poland. Leaflets of this species have been found in the Sarmatian of the Góry Świętokrzyskie Mts (Holy Cross Mts) [Zastawniak 1980, as *Podogonium oehningense* (Koenig) Kirchheimer].

Family: **Aquifoliaceae**

Ilex saxonica Mai (Pl.18, *17 & 18*; Pl. 20, *1–3*)

Ilex saxonica Mai (Mai 1964: 33; Pl. 2, Figs 19–21; Pl. 6, Figs 7 & 8)

Material. Gozdnica No. 83/24: 2 endocarps.

This is a new species for the Tertiary of Poland.

Family: **Viscaceae**

Arceuthobium oxycedroides Łańcucka-Środoniowa, *sp. nov.* (Fig. 12; Pl. 20, *4–6*)

Arceuthobium sp. (Łańcucka-Środoniowa 1980a, 63; Pl. 2, Figs 17, 19 & 20)

Fruits elliptic, slightly flattened, 1.4–2.4 mm long, 0.6–1.0 mm wide, composed of two parts; upper part formed by persistent female perianth, covered with irregular longitudinal folds; lower part covered with dense short striae.

Holotypus: KRAM-P No. 83/352; Fig. 12, *1*; Pl. 20, *4*

Locus typicus: POLAND, LOWER SILESIA, Gozdnica

Stratum typicum: Gozdnica Series, Late Miocene

Derivatio nominis: With regard to the similarity to the modern species *A. oxycedri* (DC.) Bieb.

The flattened, elliptic fruits are 1.4–2.4 mm long and 0.6–1.0 mm wide. Two separate parts are distinctly visible. The upper part is built of the preserved female perianth, usually wrinkled and covered with longitudinal and irregular, deep folds. The lower part is markedly thicker, holds a seed inside, and has its external surface finely and densely ribbed (thus giving at a highly characteristic appearance). The upper part of the pedicel persists in some fruits. A few specimens (Fig. 12, *4, 6 & 7*) were infested by fungi, whose fruit-bodies (round, black perithecia) sometimes occur in large numbers on the surface of the fruits.

Material. Gozdnica No. 83/34, 338, 352: 23 seeds.

The genus *Arceuthobium* Bieb. includes sev-

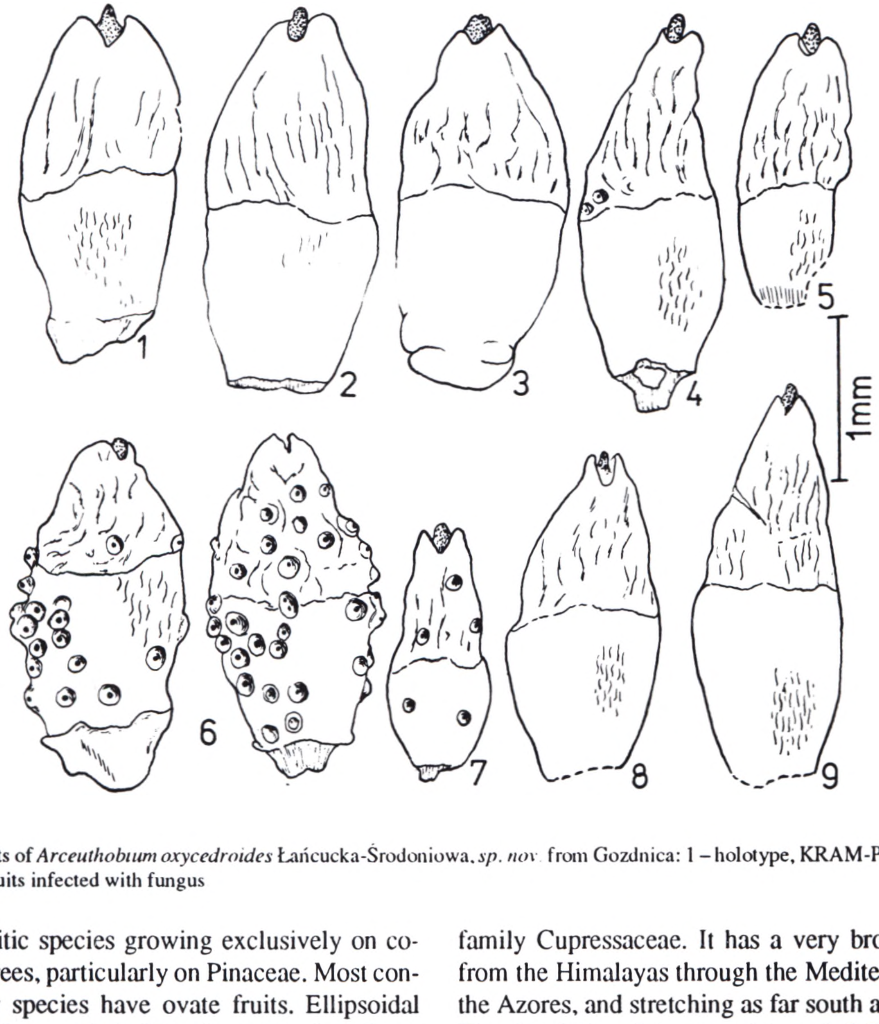

Fig. 12. Fruits of *Arceuthobium oxycedroides* Łańcucka-Środoniowa, *sp. nov.* from Gozdnica: 1 – holotype, KRAM-P No. 83/352; 4, 6 & 7 – fruits infected with fungus

eral parasitic species growing exclusively on coniferous trees, particularly on Pinaceae. Most contemporary species have ovate fruits. Ellipsoidal fruits are characteristic for only one modern European species *A. oxycedri* (DC.) Bieb. which lives on *Juniperus oxycedrus* L. *A. minutissimum* Hooker, the East Asian species (found in the West Himalayas, Pakistan, Kashmir, India, Nepal), also has small ellipsoidal fruits (2.0–2.5 x 1.5–2.0 mm) and grows on *Pinus griffithii* McClel (= *P. wallichiana* A. B. Jackson) (Hawksworth & Wiens 1972). The fruits of the North American species *A. laricis* (Piper) St. John which grows on *Larix occidentalis* Nutt., also have similar morphology to this European species. In this latter case, however, the dimensions of the ripe fruits are 1.5 x 2.5 mm (Hawksworth & Wiens 1972).

Arceuthobium oxycedri (DC.) Bieb. is the only parasitic species which grows on plants of the family Cupressaceae. It has a very broad range: from the Himalayas through the Mediterranean to the Azores, and stretching as far south as Kennya. The ripe fruits of *A. oxycedri* reach 3.0 x 1.5–2.0 mm in size.

Arceuthobium tertiaerum **Łańcucka-Środoniowa**, *sp. nov.* (Fig. 13; Pl. 20, *7–9*)

Arceuthobium sp. (Łańcucka-Środoniowa 1980a, 63; Pl. 2, Fig. 18

Fruits ovate or obovate, slightly flattened, 1.5–2.1 mm long, 1.0–1.25 mm wide, composed of two parts; upper part formed by persistent female perianth, covered with irregular longitudinal folds; lower part covered with dense short striae.

Holotypus: KRAM-P No. 83/354; Fig. 13, *1*; Pl. 20, *8*

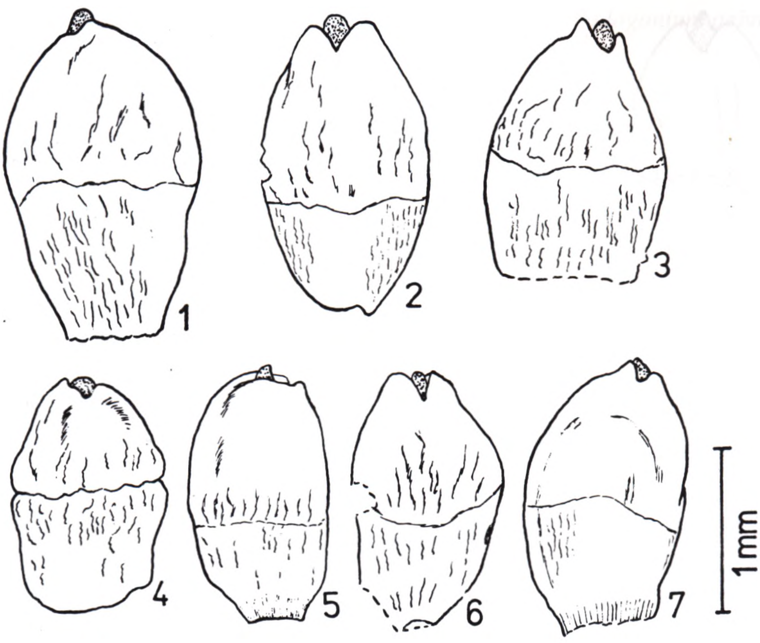

Fig. 13. Fruits of *Arceuthobium tertiaerum* Łańcucka-Środoniowa *sp. nov.* from Gozdnica; 1 – holotype, KRAM-P No. 83/354.

Locus typicus: POLAND, LOWER SILESIA, Gozdnica

Stratum typicum: Gozdnica Series, Late Miocene

Derivatio nominis: The species occuring in the Tertiary.

Two separate parts are distinctly visible in the fruits. The upper part is built of the preserved female perianths, usually wrinkled and covered with longitudinal and irregular, deep folds. The lower part is markedly thicker, holding a seed inside and has its external surface finely and densely ribbed thus giving it a characteristic appearance.

Material. Gozdnica No. 83/337, 353, 354: 7 fruits.

The fruits of this species are ovate in shape with their broadest part in the middle. In this characteristic they differ from the ellipsoidal, almost narrow oblong, fruits of *Arceuthobium oxycedroides* Łańcucka-Środoniowa, *sp. nov.* It is difficult to distinguish between these two species by fruit size as the specimens of *A. tertiaerum* are slightly immature and they could have been bigger when ripe. Almost all species of the genus *Arceuthobium* have small ovate fruits.

The contemporary genus *Arceuthobium* Bieb. includes 32 species and 6 subspecies. Most of them occur in North and Central America, with four in East Asia and one, *A. oxycedri* (DC.) Bieb., in Europe (Hawksworth & Wiens 1972).

Arceuthobium sp.
(Figs 14–17; Pl. 20, *10–16*; Pl. 21, *1–10a*; Pl. 22, *1–6*)

Arceuthobium sp. (Łańcucka-Środoniowa 1980a: 63; Pl. 2, Figs 1–16)

Various developmental stages of the male and female plants of *Arceuthobium* are represented in the material from Gozdnica. Contemporary species of *Arceuthobium* Bieb. are parasites growing exclusively on coniferous trees. The material from Gozdnica is very rich (246 total remains) and in a perfect state of preservation (Łańcucka-Środoniowa 1980a). Moreover, a small proportion of the remains represent the initial phases of development of *Arceuthobium* after a host infection (Fig. 17).

Morphology. Male specimens are illustrated in Figs 15 & 16, *4*; Pl. 20, *10–16*; Pl. 21, *6 & 7*. Shoots with staminate flowers, detached stami-

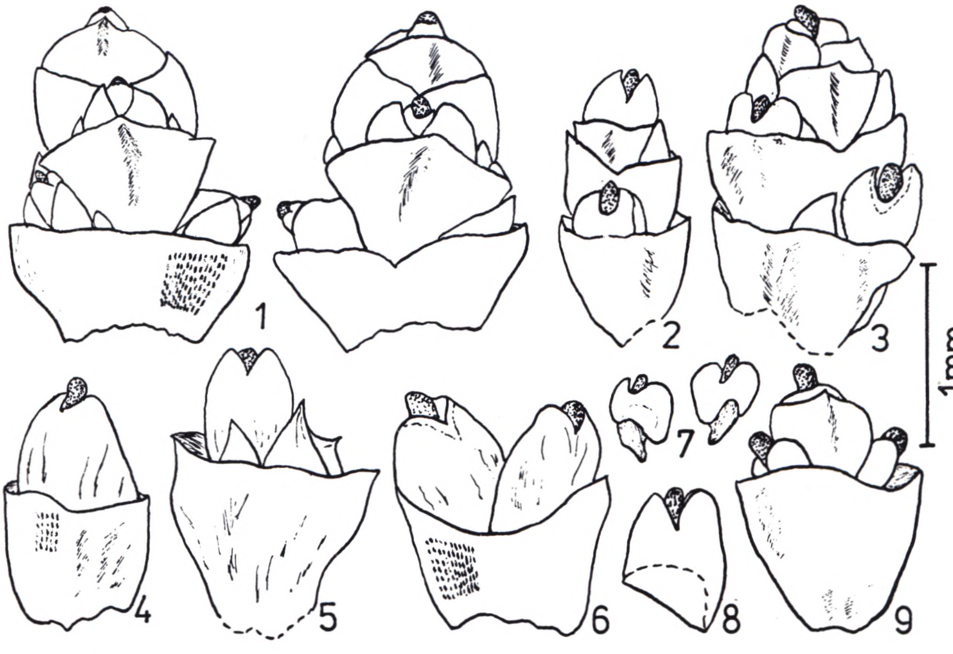

Fig. 14. Pistillate flowers of *Arceuthobium* sp. in various stages of development from Gozdnica.

nate flowers, open and closed and fragments of perianth with anthers have been preserved. The perianth is single, 3 or 4-parted, the 4-parted specimens occur perhaps even more frequently than the 3-parted ones. The length of the perianth parts are approximately 0.8–1.0 mm, width 0.4–0.68 mm. The 3-parted specimens have segments distinctly broader and blunter at the top. The open flowers are about 1.5 mm in diameter, the closed ones are over 0.7 mm. On the internal face of each part of perianth there is a flat, round anther about 0.3–0.4 mm in diameter and splits along a circular aperture. The external surface of the perianth is varnish lustrous and the rows of isodiametric cells are clearly visible.

Female specimens are illustrated in Figs 14 & 16, *5 & 11*; Pl. 21, *1–5*. Shoots with pistillate flowers, groups of pistillate flowers at the top of shoots and detached pistillate flowers have been preserved. The flowers have a single 2-parted perianth. The carpel is short and bluntly ended, the pedicel is short. Length of flowers 0.5–1.2 mm, width 0.4–0.7 mm depending on their developmental phase.

Shoots are illustrated in Fig. 16 and Pl. 21, *8 & 9*. They are segmented, with opposite leaves reduced to scales fused in pairs. The dioecius flowers are in the axils of leaves. The individual shoot segments are very small. Their length is 1.0–2.2 mm, width 1.0–1.3 mm measured at the level of the arcuately bent tops of the scale-like leaves. The biggest of the preserved shoot segments is 3.0 x 1.5 mm. The outer surface of the shoot segments is smooth and lustrous. Moreover, small remains (Fig. 17) occur which represent the initial phases of developement of *Arceuthobium* after a host infection.

Anatomy. Epidermis of twigs and bracts thickly cutinized. Cells reflected in twig cuticles (Pl. 22, *3 & 4*) arranged in fairly regular rows, isodiametric or more often elongated across the twig length, polygonal in shape, 14–30 x 20–70 µm, smaller near the twig base, with straight to slightly bent walls. Paracytic stomata scattered mostly near the twig apex, with the guard cell pairs oriented perpendicularly to the twig length. Guard cells deeply sunken, leaving only narrow traces bound by thickened stomatal ledges with a small broadly elliptic pore. Subsidiary cells large but rarely exceeding the guard cells in length, at outer periphery often darker. The size of stomata varies

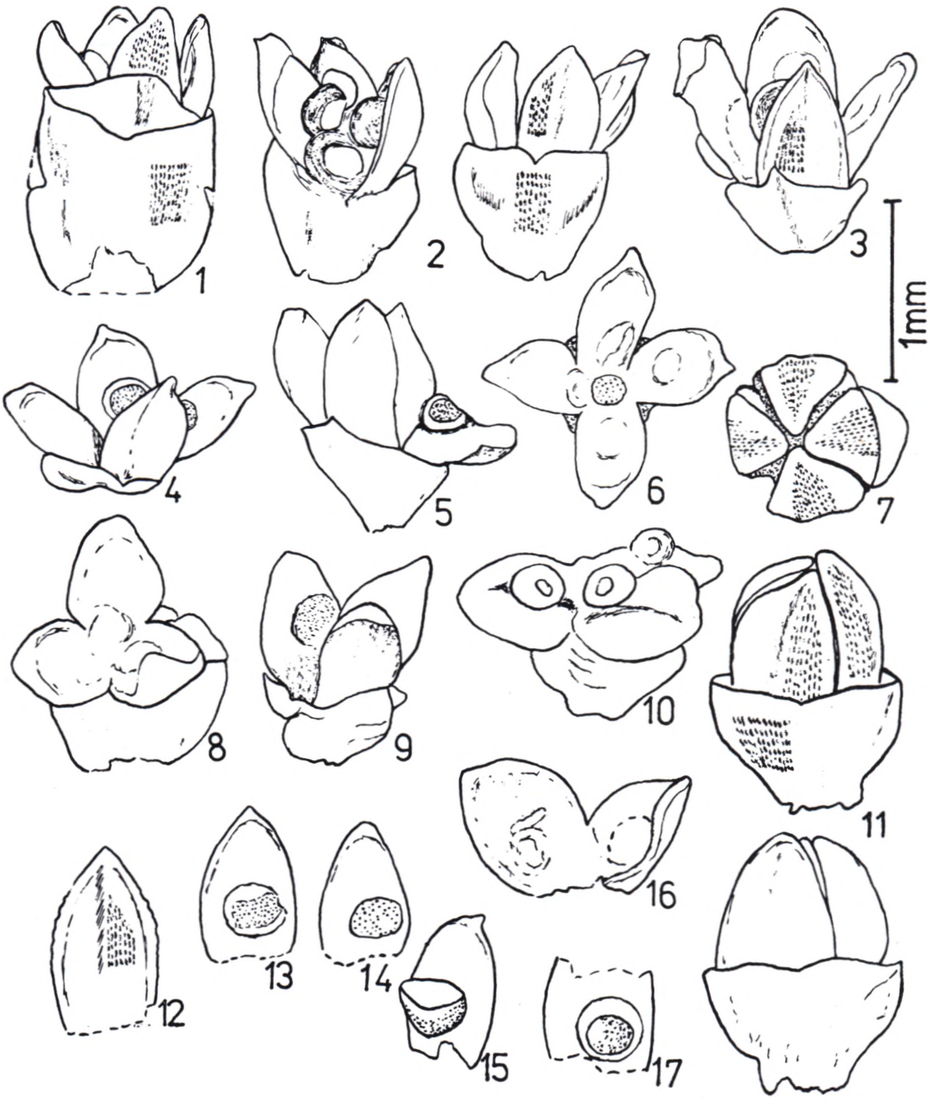

Fig. 15. Staminate flowers of *Arceuthobium* sp. from Gozdnica. 1–7: flowers 4-parted; 8–11: flowers 3-parted; 12: part of perianth with characteristic rows of isodiametrical cells on the external surface; 13—17: particular parts of perianth with round anther on the internal side, some anthers (13, 15 & 17) circularly split.

between 40–45 x 45–70 µm. Cuticles of scale-leaves thinner, cell patterns similar but less regular than in twig cuticles. Stomata of the same type and size, in 1–2 longitudinal rows on abaxial cuticle, with guard cells across the leaf length. Leaf margins slightly papillate.

Material. Gozdnica No. 83/33, 39, 323, 324, 327–336, 339–351, 355–357: 246 specimens, twigs, staminate and pistillate flowers.

The abundant and differentiated fossil remains obtained from the Neogene deposits of Gozdnica have the characteristic structure of the genus *Arceuthobium* Bieb. The modern genus includes several species (about 40 taxa) which show only very slight morphological differences. Due to this fact, to determine the species of the fossil material, on the basis of structure of shoots or flowers (staminate, pistillate) it was not possible. It is very likely

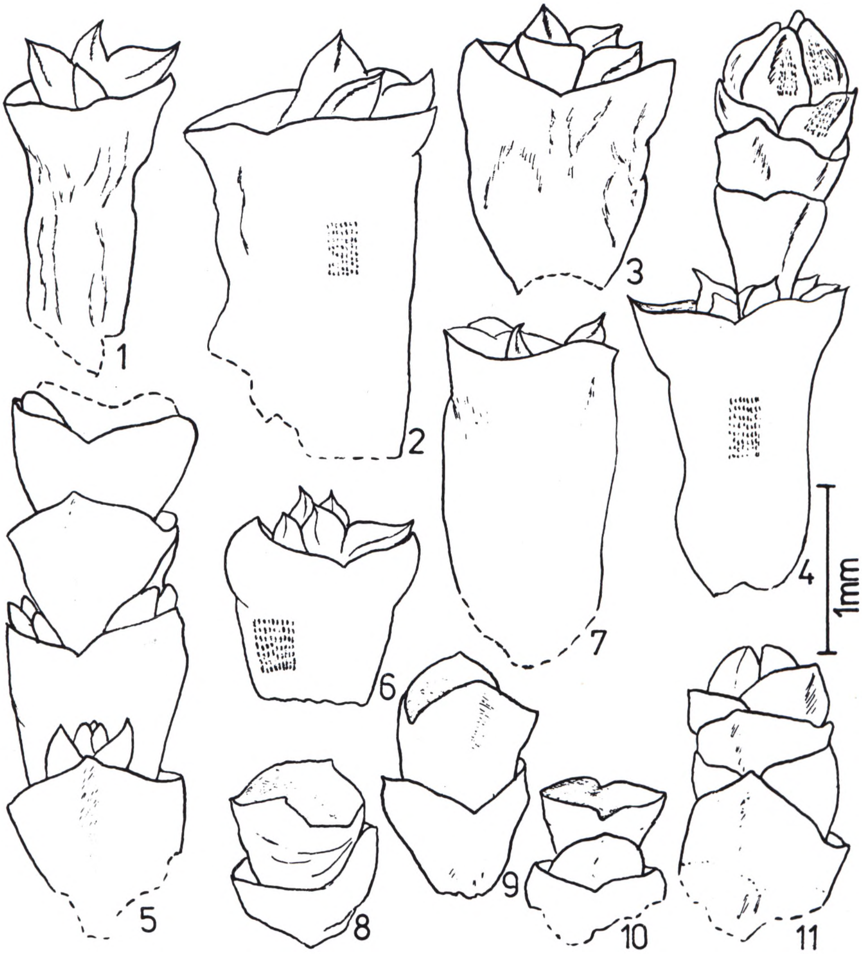

Fig. 16. Shoot segments of *Arceuthobium* sp. from Gozdnica. 1–3 & 6–10: shoot segments; 4: shoot segment with staminate flower; 5 & 11: shoot segments with pistillate flowers.

that the remains described represents more than one species, especially considering that the two fossil species *A. oxycedroides* Łańcucka-Środoniowa, *sp. nov.* and *A. tertiaerum* Łańcucka-Środoniowa, *sp. nov.* were differentiated on the basis of their fruits.

For a long time the genus *Arceuthobium* Bieb. was known in the fossil state exclusively from pollen grains occurring in deposits ranging from the Eocene to the Miocene. The genus was particularly frequent in Miocene profiles, the pollen grains occur in in Gozdnica, too (see Table 1; Figs 5 & 6). The only fossil macroscopic remains from the Pleistocene were noted from the coast of California in 1930. The remains were compared with the North-American species *A. occidentale* Engelm. which lives on *Pinus radiata* D. Don. and *P. muricata* D. Don. (after Hawksworth & Wiens 1972). For the Tertiary, the first fossil site in which the macroscopic remains of *Arceuthobium* have been found is Gozdnica (Łańcucka-Środoniowa 1980a). The fossil remains of *Arceuthobium* have also been identified occuring in the Miocene of Bełchatów (Stuchlik *et al.* 1990).

The modern genus *Arceuthobium* Bieb. includes small plants which are called dwarf mistletoes. They are all parasites growing on coniferous trees chiefly from the family Pinaceae. They spread quickly because their seeds are projected on long distances or, most likely, are dispersed by

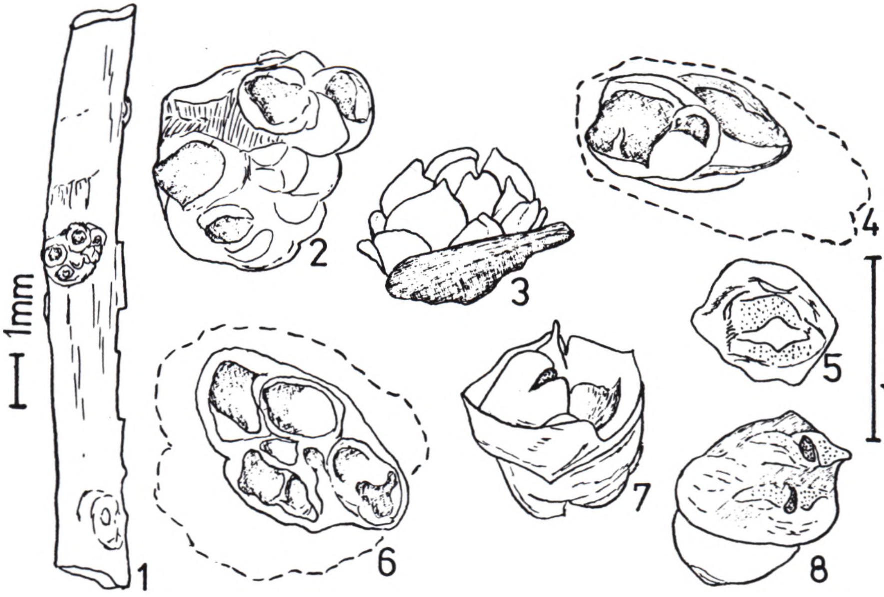

Fig. 17. Initial phases of development of *Arceuthobium* sp. after a host infection (material from Gozdnica). 1: infection of branch; 2: the same, enlargement; 3, 4 & 6: initial phases of infection with the remains of the substratum; 5, 7 & 8: other examples of the initial phase of infection.

birds. As a parasite, *Arceuthobium* causes the trees to dry. Most of the species have North- and Central American distribution and there the greatest damage to woodlands have been observed. Only a few species occur in Europe (Hawksworth & Wiens 1972; Hawksworth 1978).

Viscum miquelii (Geyler & Kinkelin) Czeczott
(Fig. 18; Pl. 21, *11*; Pl. 23, *1–6*)

Potamogeton miquelii Geyler & Kinkelin (Geyler & Kinkelin 1887: 20; Pl. 2, Fig. 4–6a & b)
Viscum miquelii (Engelhardt) Czeczott (Czeczott 1961: 76; Pl. 22, Fig. 8)
Viscophyllum miqueli (Geyler & Kinkelin) Engelhardt (Stachurska *et al.* 1971: 370; Pl. 14, Figs 1–12)

Leaves ovate, obovate to suborbiculate, mostly slightly asymmetric, 0.7–3.1 cm in length and 0.3–1.0 cm in width. Cuneate base becomes wide, petiole of up to 0.5 cm in length. Apex rounded, obtuse or retuse. Margins of leaves entire. Venation acrodromous, imperfectly seen. Two basal secondaries running in convergent arches towards the leaf apex. On their outer side yet another pair of veins, more delicate than the former, run parallel along the leaf margins. Secondaries in the upper part of the leaf joined by loops along the margin. Secondaries joined by transversal tertiary veins running at acute angles. Leaf length/width index (0.87) 1.2–2.8 (3.4) (Fig. 18).

Anatomy. Leaves amphistomatic, texture coriaceous. Epidermis of either leaf side showing the same cell patterns. Ordinary cells polygonal, straight-walled, rarely with bent anticlines, about 60 µm across, bearing very indistinct medial papilla on outer periclinal wall. Stomata paracytic, randomly oriented, with sunken guard cells preserved only in form of stomatal ledges that border spindle-like pore (Pl. 23, *5* & *6*). Subsidiary cells large, slightly darker than the ordinary cells. The length of stomata varies between 60–75 µm. Anticlinal walls distinctly pitted.

Twig fragments show forked branching on the top. Shortened segments with a pair of bracts are shown in Pl. 23, *3*. Bract cuticles bear rare stomata, and, on margins, longer papillae (Pl. 23, *2*).

Fruits rounded, flattened pseudo-berries (Pl. 23, *4*), 3–4 mm across, usually with a short stylar rest and 4 tepal scars on the top. Epicarp coriaceous, compound of isodiametric to elongate – parallel-sided cells about 30–45 µm in size and

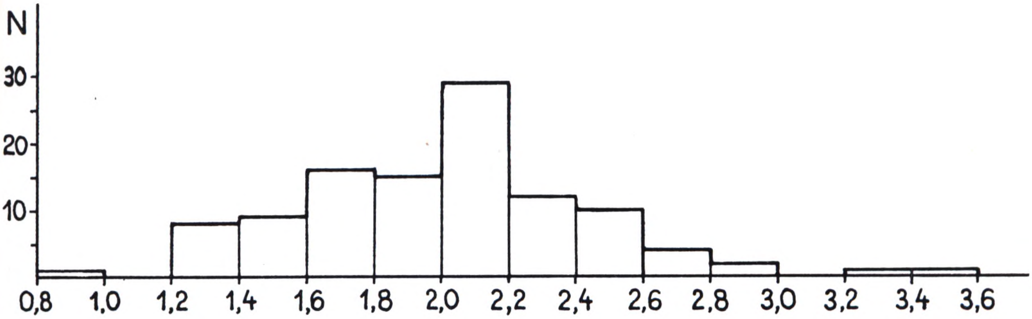

Fig. 18. Histogram of the length/width index of leaves of *Viscum miquelii* (Geyler & Kinkelin) Czeczott from Gozdnica.

bearing occasionally paracytic (aberrantly tetracytic) stomata.

Material. Gozdnica No. 83/19–22, 92–95, 302, 305, 311, 314, 318–320, 325: 17 leaves, 36 shoots, 30 fruits; Gozdnica-Stanisław No. 83/161, 217: 108 leaves, 5 shoots, 2 fruits.

Epidermis structure matches exactly with that of the topotypical material of *Viscum miquelii* (Geyler & Kinkelin) Czeczott from the Pliocene of Niederrad (Kräusel & Weyland 1954) except for indistinct papillae. This feature and the somewhat slender leaf form, indicate a relationship to the Miocene species *V. morlotii* (Unger) Knobloch & Kvaček, but the length/width index fits well with V. *miquelii*, particularly for the material from Niederrad (see Knobloch & Kvaček 1976: 68; Tab. 5).

Family: **Rhamnaceae**

Paliurus cf. *ramosissimus* Poiret (Pl. 21, *12 & 13*)

Paliurus cf. *ramosissimus* Poiret (Negru 1972: 130; Pl. 23, Fig. 8)

Material. Gozdnica-Stanisław No. 83/274: 3 fruits.

Family: **Cornaceae**

Swida sp. (Pl. 24, *1*)

Material. Gozdnica No. 6558p MGUWr: 2 endocarps.

Family: **Mastixiaceae**

Tectocarya lusatica Kirchheimer (Pl. 24, *5 & 6*)

Tectocarya lusatica Kirchh. (Kirchheimer 1934: 774; Figs 15 & 16)

Tectocarya lusatica Kirchh. (Kirchheimer 1957: 556; Pl. 42, Figs 164a–e)

Fruit 35.0 x 21.0 x 14.0 mm, elongate ovate in shape, flattened. The base rounded, the apex cuneate narrowed, furnished with a broad disc being a trace of the perianth. The fruit surface is smooth with several shallow longitudinal furrows. The only specimen found in Gozdnica is irregularly cracked showing a part of the lignified endocarp.

Material. Gozdnica No. 83/358: 1 fruit.

This extinct genus *Tectocarya* Kirchh. includes 2 fossil species: *T. lusatica* Kirchh. and *T. rhenana* Kirchh. It has frequently been found in the Oligocene and Miocene brown coal beds of West and Middle Europe. It also occurs in the Tertiary deposits of Kolchida and Bulgaria, (see Czeczott & Skirgiełło 1975). *Tectocarya* is characteristic component of mastixioidean floras and is considered to the indicate the age of the deposits.

The fruits of *T. lusatica* Kirchh. occur abundantly in the Early Miocene flora of Turów (Czeczott & Skirgiełło 1975). Gozdnica is the second site of this fossil species in Poland.

Family: **Araliaceae**

Pentapanax tertiarius Mai (Pl. 24, *7 & 8*)

Pentapanax tertiaria Mai (Mai 1973: 107; Pl. 6, Figs 1–3)

p. p. Araliaceae (Stachurska *et al.* 1971: 372; Pl. 15, Figs 4–8)

Endocarps 4.5–5.5 x 3.0–3.6 mm, almost semicircular, broad, flattened, of rather thick walls. The margin is round on dorsal face, no edges. Ventral side is almost straight. In a small depression at the apex of ventral face a micropylar aperture is seen. On the lustrous and smooth surface distinct parallel and transversally arranged strips have been observed. Some specimens split along these strips.

Material. Gozdnica No. 83/7-1: 11 endocarps.

In the family Araliaceae similarly built endocarps have hitherto been noted only in the genera *Schefflera* Forst. and *Pentapanax* Seemann. These endocarps are large, broad, smooth-walled, and without edges on the dorsal face. A characteristic transversally striping through the whole width of the endocarp indicates the genus *Pentapanax*. The modern Chinese species *P. yunnanensis* Franch. has very similar endocarps to the fossil ones (Mai 1973). The leaves of *Pentapanax* have been described from the Pliocene of Kolchida by Kolakovski (1964). The endocarps of *P. tertiarius* Mai are known from the Late Miocene of Lusatia and from the Pliocene floras of Wetterau and Thuringia (Mai 1973). Gozdnica is the only site for fossil *Pentapanax* in the Tertiary of Poland.

Family: **Labiatae**

cf. Labiatae gen. (Pl. 24, *4*)

Material. Gozdnica-Stanisław No. 83/270: 1 fruit.

Angiospermae – Monocotyledones

Family: **Alismataceae**

Alisma ex gr. *plantago* L. fossilis (Pl. 24, *2 & 3*)

Alisma ex gr. *plantago* L. fossilis (Mai & Walther 1988: 72; Fig. 8c–e)

Material. Gozdnica No. 83/29: 3 seeds.

cf. *Sagittaria* sp. (Pl. 24, *9 & 10*)

Material. Gozdnica No. 83/28: 14 seeds.

Family: **Smilacaceae**

Smilax sp. (Pl. 24, *11 & 12*)

One fragment of a leaf tip, hypostomatic. Adaxial cuticle medium thick, slightly coarsely striated, epidermal cells polygonal-lobed, 30–45 µm across, isometric to elongate (up to 80 µm long), anticlines U-shaped undulate, with slight thickenings. Abaxial cuticle (Pl. 24, *11 & 12*) thick, slightly striated parallel to main veins. Ordinary epidermal cells in costal areas rectangular-elongate, partly with oblique ends, 22–28 µm wide, with almost straight anticlines. Ordinary cells in intercostal areas polygonal-lobed, about 45 µm across with U-shaped undulate anticlines (undulations slightly finer than that in the adaxial leaf side). Stomata widely spaced, prevailingly orientated perpendicularly to the veins, paracytic (to anomocytic), guard cells slightly sunken, showing elliptic contact area with the cuticle 15–32 µm long and 15–18 µm wide and widely spindle-shaped outer cavity formed by thickened ledges reaching nearly to the poles. Subsidiary cells 2(–4) mostly on one stomatal pole fully surrounding the guard cells, rarely forming a purely brachyparacytic type.

Material. Gozdnica-Stanisław No. 83/164: 1 leaf fragment.

The epidermal structure matches well with the common species *Smilax weberi* Wessel (see Knobloch & Kvaček 1976) but the characteristics available do not allow for a secure identification to species.

Family: **Juncaceae**

Juncus sp.

Material. Gozdnica No. 83/71: 1 seed; Gozdnica-Stanisław No. 83/197, 269: 2 seeds.

Family: **Cyperaceae**

Carex caespitosa L. fossilis (Pl. 25, *1 & 2*)

Carex caespitosa L. (Jessen & Milthers 1928: 48)
Carex caespitosa L. (Mai & Walther 1988: 83; Pl. 12, Figs 1–6)

Materiał. Gozdnica No. 83/37: 8 fruits.

Carex elongatoides Łańcucka-Środoniowa (Pl. 25, *3–5*)

Carex elongatoides Łańcucka-Środoniowa (Łańcucka-Środoniowa 1979: 84; Pl. 14, Figs 4–6)

Material. Gozdnica No. 83/36: 10 fruits.

Carex flavaeformis Łańcucka-Środoniowa (Pl. 25, *6 & 7*)

Carex flavaeformis Łańcucka-Środoniowa (Łańcucka-Środoniowa 1979: 89; Pl. 14, Figs 18 & 19)

Material. Gozdnica-Stanisław No. 83/177, 244: 4 fruits.

Carex cf. *plicata* Łańcucka-Środoniowa (Pl. 25, *8 & 9*)

Carex plicata Łańcucka-Środoniowa (Łańcucka-Środoniowa 1979: 90; Pl. 14, Figs 20–25).

Material. Gozdnica-Stanisław No. 83/182, 245, 246: 88 fruits.

In their size and shape the fruits mostly resemble those of *Carex plicata* Łańcucka-Środoniowa, but transverse furrows are poorly marked and are visible only in a few specimens.

***Carex* cf. *ungeri* Mai** (Pl. 25, *10 & 11*)

Carex ungeri Mai (Mai & Walther 1988: 87; Pl. 12, Figs 18 & 19)

Material. Gozdnica-Stanisław No. 83/247, 248: 6 fruits.

Carex sp. 1 (Pl. 25, *12 & 13*)

Material. Gozdnica No. 83/291: 2 fruits.

Carex sp. 2 (Pl. 25, *14*)

Material. Gozdnica No. 83/292: 1 fruit.

Caricoidea globosa (C. & E. M. Reid) Mai (Pl. 25, *15 & 16*)

Hippuris globosa C. & E. M. Reid (C. & E. M. Reid 1915: 123; Pl. 14, Fig. 24)
Caricoidea globosa (C. & E. M. Reid) Mai (Mai & Walther 1978: 140)

Material. Gozdnica No. 83/30, 30–1: 45 fruits; Gozdnica-Stanisław No. 83/180: 8 fruits

Cladium sp.

Material. Gozdnica-Stanisław No. 83/253: 1 fruit.

Cyperus sp. (Pl. 25, *17 & 18*)

Material. Gozdnica No. 83/70, 70–1: 10 fruits.

Dulichium arundinaceum (L.) Britton fossilis (Pl. 26, *1 & 2*)

Dulichium arundinaceum (L.) Britton fossilis (Mai & Walther 1988: 90; Pl. 13, Figs 28–32)

Material. Gozdnica-Stanisław No. 83/186, 259: 5 fruits.

Dulichium marginatum (C. & E. M. Reid) Dorofeev (Pl. 25, *19–22*)

Dulichium spathaceum Rich. var. *marginatum* C. & E. M. Reid (C. & E. M. Reid 1915: 66; Pl. 3, Figs 5 & 6)
Dulichium marginatum (C. & E. M. Reid) Dorofeev (Dorofeev 1963: 117; Pl. 13, Figs 17–23)

Material. Gozdnica-Stanisław No. 83/185, 257, 258: 9 fruits.

Trichophorum silesiacum Łańcucka-Środoniowa, *sp. nov.* (Pl. 26, *3–6*)

Fruits without a beak 1.4–1.7 x 0.5–0.7 mm, trigonous, elongate-elliptic in outline. Three thick edges. Apex furnished with trigonous blunt beak about 0.2 mm long. Base strongly cuneate narrowed, blunt. Longitudinal rows of isodiametric cells are seen on lateral lustrous surfaces. Bristles are smooth, almost as long as the fruit, in number of 6.

Holotypus: KRAM-P No. 83/256, Pl. 26, *3*
Locus typicus: POLAND, LOWER SILESIA, Gozdnica
Stratum typicum: Gozdnica Series, Late Miocene
Derivatio nominis: From the Silesian region.

Fruits without a beak 1.4–1.7 x 0.5–0.7 mm (most frequent 1.5 x 0.5 mm), trigonous, narrow-elliptic-elongate, seldom somewhat broader, elongate obovate. Length/width ratio is about 3.0. Three thick edges. The apex with trigonous blunt beak about 0.2 mm long. The base is strongly cuneate narrowed, blunt. The lateral walls are thick, flat and lustrous, the surface is minutely, delicately pitted (longitudinal rows of isodiametric cells are seen). Six bristles equal to the fruit length. In most specimens these fragile bristles are partly broken or not preserved at all.

Material. Gozdnica-Stanisław No. 83/254–256: 26 fruits.

Fossil fruits are similar to the genus *Trichophorum* Pers. which has quite smooth bristles in contrast to other genera from the subfamily Scirpoideae: *Scirpus* L., *Bulboschoenus* (Aschers.) Palla, *Schoenoplectus* (Reichenb.) Palla, *Schoenus* L. (Kowal 1958). The specimens from Gozdnica show some morphological similarity to *T. caespitosum* (L.) Hartm. but differ by being considerably narrower and, therefore, can not be linked with the modern species growing at the lake shores and peat-bogs of Eurasia today.

The fruits of cf. *Trichophorum* sp. found in the Pliocene deposits in Czecho-Slovakia (Bůžek *et al.* 1985: 35; Pl. 18, Figs 5–10) were compared with *T. caespitosum* (L.) Hartm. from Gozdnica. Almost all of them are considerably broader. At present five species in Eurasia and one in South America (Bolivia) are known.

Scirpus sylvaticus L. fossilis (Pl. 26, *7 & 8*)

Scirpus sylvaticus L. fossilis (Schröder & Stoller 1908: 426)
Scirpus sylvaticus L. fossilis (Mai & Walther 1988: 93; Fig. 22e–h Pl. 13, Figs 39–42)

Material. Gozdnica-Stanisław No. 83/283, 284: 15 fruits.

Scirpus ragozinii Dorofeev (Pl. 26, *9 & 10*)

Scirpus ragozinii Dorofeev. (Dorofeev 1963: 123; Pl. 13, Figs 38–45 & Fig. 18: 1–6)

Material. Gozdnica No. 83/39: 1 fruit; Gozdnica-Stanisław No. 83/183, 285: 20 fruits.

Family: **Gramineae**

cf. Gramineae gen. (Pl. 26, *11*)

Material. Gozdnica No. 83/46: 2 fruits.

Family: **Araceae**

Epipremnites reniculus (Ludwig) Mai (Pl. 26, *13*)

Cytisus reniculus Ludwig (Ludwig 1857: 101; Pl. 20, Fig. 21)
Epipremnum crassum C. & E. M. Reid (C. & E. M. Reid 1915: 71; Pl. 4, Fig. 1–9)
Epipremnum ?reniculum (Ludwig) Kirchh. (Kirchheimer 1935a: 79; Pl. 11, Fig. 33a–i)
Epipremnum crassum C. & E. M. Reid (Łańcucka-Środoniowa 1979: 92; Pl. 15, Fig. 1, 2)
Epipremnites reniculus (Ludwig) Mai (Mai 1989: 40; Pl. 8, Figs 21 & 22)

Material. Gozdnica-Stanisław No. 83/260: 1 seed.

Family: **Sparganiaceae**

Sparganium cf. *nanum* Dorofeev

Sparganium nanum Dorofeev (Kolakovsky 1958: 324–325; Pl. 17, Figs 2–5)

Material. Gozdnica No. 83/53: 1 endocarp.

Family: **Typhaceae**

Typha sp. (Pl. 26, *12*)

Material. Gozdnica-Stanisław No. 83/288: 1 seed.

Incertae sedis

Carpolithes natans Nikitin *ex* Dorofeev (Pl. 26, *14 & 15*)

Carpolithus natans Nikitin (Dorofeev 1963: 277; Pl. 49, Figs 13–15)

Material. Gozdnica No. 83/35: 7 seeds; Gozdnica-Stanisław No. 83/181: 2 seeds.

Carpolithes sp. (Pl. 26, *17–20*)

Material. Gozdnica No. 83/52–1: 4 fruits.

REMAINS OF WOOD FROM GOZDNICA-STANISŁAW PROFILE 2
(W. PYSZYŃSKI)

A single sample, 15 x 10 x 2 cm (long. x tang. x rad.), and a number of smaller ones, 2–5 x 1–2 x 0.5 cm, exhibited a light-reddish-brown colour. Two others, 12 x 6 x 2 and 7 x 6 x 3 cm big, were dark-reddish-brown. From macroscopic examination alone, it appeared that the lighter colours samples are conifers and that the darker ones are from deciduous trees. The darker samples have ring-porous wood and oak-type rays.

In the course of the preliminary attempts to determine the wood's origin, the material was prepared in the traditional way: boiled in water with KOH and sectioned by hand. This treatment badly affected the material, especially the conifers wood, as the sections became brittle and fell into pieces, particularly the transverse sections. Thus the paraffin method (used in the histology of soft tissues) and which was previously successfully applied to the Pleistocene wood preperations (Pyszyński *et al.* 1991; Pyszyński 1991), was adopted. The splits were also prepared and their surface observed using a MBI microscope with, 'epi' illumination, and a MBS stereomicroscope.

The following keys were used in the course of determination of wood samples: Gothan 1905; Greguss 1945, 1955; Schweingruber 1978; Panshin & de Zeeuw 1980.

Family: **Taxodiaceae**

Taxodioxylon taxodii Gothan
(Pl. 27, *1–4*; Pl. 28, *1–5*; Pl. 29, *1* & *2*)

Taxodioxylon taxodii Gothan (Gothan 1906: 176; Figs 1 & 4)

Transverse section. The microscopic analysis reveals that the wood lacks resin canals and exhibits distinct growth rings (Pl. 27, *1* & *2*). In general, the transition from early to late wood is sharp. The early wood is compressed in its radial direction, which is manifested by the oblique orientation of rays and longitudinal thin-walled elements. The cells of the late wood are arranged along the geometric radius; i.e. perpendicular to the surface of a growth ring. The late wood consists of 3–4 layers of rectangular cells, whose tangential dimensions equal 40 μm, and radial dimensions are 15–30 μm. The average thickness of the growth ring, estimated on the basis of the ray length, is 800 μm. The parenchyma cells have a dark resinous content (Pl. 27, *1* & *2*), appear singly or side by side and form distinct bands within the late wood.

Tangential section. There are small bordered pits (2–5 μm in diameter) scattered irregularly in the tangential walls of the late wood (Pl. 28, *1*). Rays are generally uniseriate or partly biseriate (Pl. 27, *3* & *4*; Pl. 28, *1*). Their height varies from 1 to 30 cells (mostly 7–10). The longitudinal walls of the longitudinal parenchyma cells are pitted (simple pits) whereas their horizontal walls are nodular (Pl. 28, *2* & *3*). There are globular brown congregations of resin inside the cells (Pl. 27, *3* & *4*; Pl. 28, *2*).

Radial section. Bordered pits arranged in 1–3 rows occur in the radial walls of tracheids (Pl. 28, *4* & *5*). Their diameter usually equals 16 μm. Between the pits there are distinct crasullae (bars of Sanio). Ray parenchyma cells extend radially. The outer walls of marginal cells are usually plane, and only in some places slightly convex (Pl. 29, *1*). In the cross fields of early wood there are 2–3–4 taxodioid pits (average diameter 8 μm) arranged in single rows (Pl. 29, *1*). Their borders are narrow, and their apertures horizontal or slightly oblique. There can be two rows of pits in the marginal cells (Pl. 29, *2*). The shape and dimensions of the pits are the same for both marginal and inner ray cells. There are simple pits in the horizontal walls between the ray cells (Pl. 29, *1*). The tangential walls of the cells are always thin and smooth, vertical, oblique or curved (Pl. 29, *1*).

All the features mentioned above indicate that the analysed wood belongs to the Taxodiaceae, genus *Taxodioxylon* Hartig. The comparison of this wood with that of living species indicates that it is significantly similar to the wood of *Taxodium distichum* Rich. The similarity is seen mainly in the type of pits in the cross fields, the occurrence of bordered pits in 1–3 rows in the radial walls of tracheids, and the nodular structure of horizontal walls of the longitudinal parenchyma.

The comparison of the wood under analysis with the woods of living and fossil species, allows one to conclude, that the analysed wood is *Taxodioxylon taxodii* Gothan (Gothan 1906: 17; Figs 1–4). This species was common in Lower Silesia (Prill & Kräusel 1919; Kräusel 1920; Zalewska 1953, 1955; Kostyniuk 1967) and adjacent areas: Lower Lusatia (Gothan 1906) and Silesia (Reyman 1956) during the Tertiary. Fossil wood exhibiting similar anatomical features were also found in other regions of Poland (Lilpop 1929; Kostyniuk 1938; Kownas 1951; Grabowska 1956; Smólska 1959) and Central Europe (Greguss 1967).

Family: **Fagaceae**

Quercoxylon sp. (Pl. 29, *3*; Pl. 30, *1–4*)

Transverse section. Microscopic analysis reveals that in the early wood, large vessels (0.25 mm in diameter) are arranged in 2–3 tangential bands. They are usually flattened and extended radially (often considerably), which reflects that they were pressed from one side, tangentially to the circumference (Pl. 29, *3*).

In some places, the deformations are slight and the structure of tissues can be easily identified. Tyloses, characteristic of heartwood, often occur in vessels.

Tangential section. In this section, two main types of rays, either narrow uniseriate (only sometimes biseriate) or multiseriate, can be seen (Pl. 30, *1*). The rays equal 1–20 cells in height (average 12–15). Their cells are slightly extendend longitudinally and average 18 x 15 µm. Multiseriate rays reach 1 cm in height and 0.1–0.5 mm in width (up to 30 cells). The diameter of their parenchyma cells varies between 8 x 8 to 20 x2 0 µm.

Radial section. There are bordered pits with circular or flattened apertures in the tracheary elements (Pl. 30, *2*). In the places where the ray parenchyma make contact with the vessels, pits with big vertical or slightly oblique apertures occur (Pl. 30, *3*). Ray parenchyma cells are homogenous and filled with brown material (Pl. 30, *4*).

All the above features indicate that the analysed wood belongs to the genus *Quercoxylon* Hoffm. It is difficult, however, to determine the species exclusively on the basis of wood analysis.

It should be emphasised, that it is also very difficult, or even impossible, to determine the species of the wood from living *Quercus* L. taxa (Krzysik 1970; Schweingruber 1978; Panshin & de Zeeuw 1980). Comparison of the analysed specimens with the woods of living species indicates only that they are very similar to *Quercus cerris* L. a native of Southern Europe. This suggestion is supported, in particular, by the distribution and size of vessels in the wood, the occurrence of a few scattered vessels in the late wood and the dimensions of the uni- and multiseriate rays. Also, the fact that the remains of *Quercus* sect. *Cerris* Spach. were found in the Pliocene flora of Ruszów (Hummel 1983), located only 6 km away from Gozdnica, supports the suggested determination of the analysed material.

It should be emphasised, that, until now, deciduous woods dated to the Miocene have not been recorded for Lower Silesia.

VEGETATION RECONSTRUCTION OF THE GOZDNICA AND GOZDNICA-STANISŁAW LOCALITIES ON THE BASIS OF THE MACROSCOPIC REMAINS

(Z. KVAČEK)

The vegetation reconstruction of the Gozdnica and Gozdnica-Stanisław localities relies only on an autecological analysis of the individual plant groups and their relative representation in the total sample. Any taphonomic study is impossible because sampling was carried out irregularly and without any recording of the actual depositional environment. In general, however, we may assume that the fossiliferous deposits correspond to a channel filling of a stream near the basin. The whole assemblage is highly allochthonous.

The prevailing tree elements - *Pinus* (*Strobus*), *Sequoia*, *Fagus* and *Betula* give a picture of a mixed coniferous and deciduous broad-leaved forest with a double tree storey and containing some partly evergreen shrubs in the undergrowth:

– canopy trees: *Pinus* (*Strobus*), *Sequoia*, *Fagus* dominant, with accessory *Pinus* (*Pinus*), *Betula*, *Tsuga*, *Taxodium*, *Quercus*, *Liquidambar*, *Carya*, *Gleditsia*,

– understorey trees: *Tetraclinis salicornioides*, Cupressaceae, *Carpinus*, *Mastixia* Blume, *Ostrya* Scop., *Eurya*, *Styrax*, *Magnolia*, *Symplocos*, *Tectocarya*,

– shrubs: *Hypericum* (p. p.), *Clethra*, Ericaceae, *Boehmeria* Jacq., *Ilex*, *Myrica*, *Paliurus* Miller, *Swida*; partly ascending – *Rubus* L., *Pentapanax*, *Tetrastigma*, *Smilax* L., Melastomataceae,

– herbs poorly represented by *Carex*, cf. *Stellaria*, *Rumex* L., Chenopodiaceae, *Alchemilla* L., *Alisma* L., *Juncus* L., *Cladium* Browne, *Cyperus* L., *Duli-*

chium Persoon, *Epipremnum* Schott, *Sparganium* and *Typha* L.

The forest is reminiscent of the hardwoods forest of the south-east North America, with additional redwoods. The combination of *Sequoia* and white pine on one side and *Taxodium*, white pine, beech and birch enriched by *Gleditsia* and *Liquidambar* on the other indicate moist alluvial lowland conditions in a warm-temperate climate. The understorey, however, has much in common with the Mixed Mesophytic Forest of East Asia (*Eurya, Symplocos, Pentapanax*, Melastomataceae, Mastixiaceae) and give the forest a more subtropical aspect. The rather high representation of *Taxodium* and *Nyssa* tell us that fragments of back swamp forest were transported into the channel. The forests were obviously extensive and grew on lowlands and levees along the stream. Lianas (*Epipremnum*) and thickets covered the ground rather than herbs, which are rare – except for marshy plants on open streamside habitats. The forests were heavily populated with mistletoes and dwarf mistletoes. Other epiphytes (e.g. *Pentapanax, Smilax*), which would have climbed out of the tree shade, also occurred.

Aquatic plants of standing water are poorly represented. Some elements (*Myrica, Ilex*, Ericaceae, etc.) refer to well drained acid soils, or even peat bogs, but only *Taxodium-Nyssa* stands with *Proserpinaca* L. and *Aldrovanda* L. could withstand permanent swamp conditions. White pines are today common admixtures of hardwood forests in the United States and *Pinus monticola* Dougl. *ex* D. Don is one of the first trees to colonize peat bogs. A combination of beech with yellow birch, *Liquidambar* and *Gleditsia*, is more characteristic of lowlands of the southern United States.

The ecotone between the forest and streamside vegetation was probably inhabited by *Rubus, Hypericum* L., *Lyonia*, Lythraceae, *Swida, Paliurus* and others. The open streamside habitats and marshes were covered by Cariceta with *Carex* sp. div., *Cladium, Cyperus, Dulichium, Ludwigia, Sparganium, Typha*, and in deeper water with *Scirpus, Sagittaria* L., *Alisma*.

AGE OF THE MACROFOSSILS FROM GOZDNICA AND GOZDNICA-STANISŁAW LOCALITIES AND THEIR COMPARISON WITH OTHER NEOGENE FLORAS

(E. ZASTAWNIAK)

From the very beginning of its study, the fruit-seed flora from Gozdnica created great difficulties in the interpretation of its age. Although the geological data rather indicate a fairly young, even Pliocene, age for the flora-bearing sediments, the authors of the first publication (Stachurska *et al.* 1971) assumed to a Mio-Pliocene date, on account of the presence, and even predominance, of species known from Miocene formations from Central Europe. They were *Pinus leitzii* Kirchh., *Sequoia langsdorfii* (Brongn.) Heer, *Tetraclinis articulata* (Vachl.) Masters, *Myrica ceriferiformis* Kownas, *Eurya stigmosa* (Ludwig) Mai, *Nyssa disseminata* (Ludwig) Kirchh., *Symplocos lignitarum* (Quenstedt) Kirchh., *S. minutula* (Sternb.) Kirchh., *Viscophyllum miquelii* (Geyler & Kinkelin) Engelhardt and *Carpolithes natans* Nikitin *ex* Dorof. The results of a palynological analysis of the profile from Gozdnica (Stachurska *et al.* 1971, Fig. 5) also pointed to the atypical nature of its vegetation, which combined elements characteristic of both the Pliocene and the Miocene, and which could, therefore, not be compared with any Younger-Tertiary flora known earlier from Poland.

The sediments of the Gozdnica Series, from which the fossil flora under study is derived, lie above those of the Poznań Series, and this indicates that the deposition of this rock series did not start before the sedimentation of the Poznań Series had been completed (cf. p. 10). On the basis of the palynological analysis Sadowska (cf. p. 15) determined the age of the top portion of the Poznań Series as Late Sarmatian and assumed that the profiles of the Gozdnica Series were younger than Sarmatian.

A comparison between the floristic composition of these two taphocenoses, i.e., one from the outcrop in the Gozdnica clay-pit (profile 3/71, Table 3 Gozdnica A + Gozdnica B) and the other from the outcrop in the Gozdnica-Stanisław claypit (profile 2, Table 3 Gozdnica -Stanisław C), shows that the fossil remains of the same mixed *Pinus-Sequoia-Fagus* forest are dominant in both floristic complexes. Furthemore, the floras also similar in composition and proportions of accompanying species, the proportion of the palaeotropical element and that of the native, exotic and extinct taxa. The presence of the species *Tectocarya lusatica* Kirchh., was, at first, the only component of the mastixioidean flora recovered, however, further investigation and identification yielded additional species/genera from mastixioidean flora. In 1991 A. Sadowska took samples from profile 3/71 of the Gozdnica clay-pit. This contained many *Eurya stigmosa* (Ludwig) Mai seeds, the fruits of various species of *Symplocos* Jacquin, which included, for example, *S. lignitarum* (Quenst.) Kirchh., *S.* cf. *schereri* Kirchh., *S. salzhausensis* (Ludwig) Kirchh., *S. minutula* (Sternb.) Kirchh., and also *Sphenotheca incurva* Kirchh., *Eomastixia persicoides* (Unger) Mai *ex* Gregor, *Styrax maxima* (Weber) Kirchh., *Mastixia thomsonii* Mai, *Tetrastigma chandleri* Kirchh., *T.* cf. *lobata* Chandl., *Carya* cf. *ventricosa* (Sternb.) Unger, *Magnolia lignita* (Ung.) Mai, *Ilex lusatica* Menzel and *Acer pseudodiabolicum* Baranowska-Zarzycka (*det.* M. Łańcucka-Środoniowa).

In the higher-lying profile 2 from Gozdnica no remains of mastixioidean flora were found except for the fruits of *Symplocos*. However, as the compositions of both taphocenoses are in principle identical, it would be difficult to interpret not finding mastixioidean planst remains in the higher profile as due to a different age of the sediments.

Taking into consideration all the taxa of fruits, seeds and leaf remains, we may state that the flora from Gozdnica is characterized by the proportion of the palaeotropical element. This element reaches 33% and is represented by the following taxa: *Clethra* L., *Eurya* Thunberg, *Eomastixia* Chandler, *Mastixia* Blume, *Magnolia* L., *Melastomites* Unger, *Ilex* L., *Symplocos* Jacquin, *Sphenotheca* Kirchh., *Styrax* L., *Tetrastigma* Planchon, '*Viburnum*' *atlanticum* Ett., *Vaccinioides lusatica* (Litke) Kvaček & Walther, cf. *Pirocarpella* Mai, *Tectocarya* Kirchh., Araliaceae, *Smilax* L., *Pentapanax* Seemann, *Caricoidea* Chandler and *Epipremnites* Gregnor & Bogner. The extinct and form genera (*Sphenotheca, Eomastixia, Vaccinioides* Kvaček & Walther, *Melastomites, Microdiptera* Chandler, *Tectocarya, Caricoidea,* cf. *Pirocarpella* Mai) make up 12% of the total number for the genera (cf. Table 5). Such high percentages from the palaeotropical element from extinct and form genera and the occurrence of taxa characteristic of the mastixioidean floras (cf. Mai 1965a) distinguish the Gozdnica assemblage from all the other Younger-Tertiary floras of Poland. Even the mastixioidean flora from Wieliczka has a far lower palaeotropical element and far fewer extinct genera (Łańcucka -Środoniowa 1984). The community of mixed *Pinus-Sequoia-Fagus* forest, characteristic of the Gozdnica flora, appears to be a typical community of this loacality, not having hitherto been found either in the floras of the Middle Miocene (Wieliczka, Konin, Rypin, Mirstowice, Stare Gliwice and Chyżne) or those of the

Table 5. Proportion of elements in the comparable fossil floras (in %).

Elements \ Locality	Salzhausen (Mai & Gregor 1982) Middle Miocene	Gozdnica (this paper) Late Miocene	Hambach (Van der Burgh 1987) Late Miocene	Fortuna (Van der Burgh 1987) Late Miocene	Niederlausitz (Mai 1989)	Ruszów (Baranowska-Zarzycka 1988), Early Pliocene
Palaeotropical	50	33	32.5	32	16	12.5
Arctotertiary	50	67	67.5	68	84	87.5
Exotic	73	42	44	51	32	36
Native	27	46	36	35	57	54.5
Extinct + form genera	12	12	19	14	11	9

Mio-Pliocene (Sośnica) and of the Pliocene (Krościenko, Ruszów and Kłodzko) of Poland.

On the other hand, noteworthy are the high percentages of the arctotertiary (67%) and native (46%) elements in the flora of Gozdnica, much higher than in the floras of the Middle Miocene, e.g., of Salzhausen (cf. Table 5). This suggests a younger age for the Gozdnica flora, since equally high proportions of the arctotertiary and native elements are characteristic of the Late Miocene and Pliocene floras of Europe, including the so-called younger mastixioidean floras (Mai 1964, 1965a). The upper boundary for the occurrence of younger mastixioidean floras in Europe was at first placed in the Middle Miocene (among others, Salzhausen, see Mai & Gregor 1982) and Wieliczka (Badenian) in southern Poland was considered to be the latest locality for these floras (Zabłocki 1928, 1930; Mai 1964, 1965a, Łańcucka-Środoniowa 1984). A later study carried out on fossil floras in the Lower Rhineland caused boundary to shift to the Late Miocene (Van der Burgh 1987). Here the outcrops in the open coal mines at Fortuna and Hambach near Düren in the Netherlands are particularly interesting in connection with the Gozdnica flora under study.

The fruit-seed flora of Fortuna comes from the so-called Fischbach-Schichten, lying over the Garzweiler seam, which is referred to the upper part of the Middle Miocene (Zagwijn & Hager 1987). Abundant and perfectly well preserved plant macrofossils occur there in sandy deposits filling the channel of an ancient river. The geological situation is, therefore, similar to that at Gozdnica. The sands at Fortuna were first considered, just as at Gozdnica, to be Pliocene in age (Van der Burgh 1987: 301), but on acount of the presence of a mastixioidean flora in them they have been attributed to the Late Miocene (Indener Formation).

The Gozdnica and Fortuna floras are characterized by similar values of palaeofloristic elements (cf. Table 5); they have 32 genera in common: 12 palaeotropical (*Caricoidea, Eomastixia, Epipremnites, Eurya, Ilex, Magnolia, Mastixia, Sphenotheca, Styrax, Symplocos, Tectocarya* and *Tetrastigma)* and 20 arctotertiary *(Acer* L., *Carex* L., *Carya* Nutt., *Ceratophyllum* L., *Chenopodium* L., *Cladium* Browne, *Fagus* L., *Hypericum* L., *Liquidambar* L., *Myrica* L., *Nyssa* Gronovius, *Ostrya* Scop., *Proserpinaca* L., *Rubus* L., *Sparganium* L., *Scirpus* L., *Sequoia* Endl., *Stellaria* Brown, *Taxodium* Rich. *and Viscum* L.). The plant taxa associated with wetland forests predominate at Fortuna (*Sequoia, Fagus, Eurya* and *Mastixia*). The great abundance existnce of *Sequoia* remains in the Late Miocene of the Lower Rhineland and in Lower Silesia indicate significant role that this tree played in the landscape of that time, brought about by exceptionally favourable environmental and/or climatic conditions.

The only difference that can be noted between the composition of the two floras under comparison concerns pine, which is missing at Fortuna but whose numerous remains [*Pinus leitzii* Kirchh., *P. spinosa* Herbst and *P. thomasiana* (Goepp.) Reichenbach] occur in the neighbouring coast mine at Hambach (Van der Burgh 1987). They are accompanied by the abundant remains of fruits and seeds, which originate from the sands of a river channel beneath the Indener Formation or from the shallow channels in the top clay. The flora from Hambach has approximate values of palaeotropical elements (cf. Table 5) as the Gozdnica flora; 34 genera being common to them, namely, 13 palaeotropical (*Caricoidea, Eomastixia, Epipremnites, Eurya, Ilex, Magnolia, Mastixia, Microdiptera, Sphenotheca, Styrax, Symplocos, Tectocarya* and *Tetrastigma)* and 21 arctotertiary genera [*Acer, Alisma* L., *Betula* L., *Carex, Carpinus* L., *Ceratophyllum* L., *Dulichium* Persoon, *Fagus, Liquidambar, Myrica, Nyssa, Ostrya, Pinus* L., *Proserpinaca, Rubus, Scirpus, Sparganium, Sequoia, Swida* Opiz (*Cornus* L.), *Taxodium* and *Vaccinium* L.]. At Hambach, as at Gozdnica, the bottom and slopes of the river valley were overgrown by mixed coniferous and deciduous broad-leaved forests of the same type, showing various requirements as to the ground water regime [wetland forest – floodplain forest – upland forest (cf. Van der Burgh 1983, 1987)], with the trees of *Pinus, Sequoia* and *Fagus* dominant in the canopy layer and mainly *Eurya, Symplocos* and *Tectocarya* in the understorey.

Van der Burgh (1987) explains the extraordinarly high proportion of the palaeotropical element, as far as fossil floras of the Late Miocene are concerned, at Fortuna and Hambach by the presence of more oligotrophic edaphic factors, while the predominance of the arctotertiary element was due to sufficiently nutrient conditions in other habitats, mostly in valley bottoms. The plants, now associated with the tropics and subtropics, survived, in Van der Burgh's opinion, in relict areas of the Lower Rhine basin, in river valleys or in some sheltered places in coastal areas.

This problem, however, has a somewhat different interpretation in the light of the palynological analysis of the deposits from Hambach. The pollen diagram (short version) published by Zagwijn & Hager (1987) reflects a phase a considerable climatic warming, to warm or subtropical temperatures, occurring between two periods of temperate climate. This phase is characterized by the dominance of evergreen tree pollen grains and large quantities of *Mastixia* and *Symplocos*. This warming occurs within the Indener Formation, from which the two fruit-seed floras of Fortuna and Hambach with which we are concerned come. In accordance with the biostratigraphic zonation of the marine Neogene of the Netherlands (Zagwijn & Hager 1987, Fig. 9), the phase of warming in this area corresponds to the palynological Linne B/C stages (previous Susterian) in the Late Miocene. In the pollen diagrams from Gozdnica• (Stachurska *et al.* 1971, Fig. 5) and Gozdnica-Stanisław (Sadowska, this paper, Fig. 6 & Table 2) the proportion of more thermophilous plants [Actinidiaceae, Cyrillaceae-Clethraceae, *Ilex*, Rutaceae, Sapotaceae, *Symplocos*, *Tricolporopollenites edmundi* (Potonié) Thomson & Pflug] is also noticeable. It seems, therefore, very probable that the Gozdnica vegetation of that time, just like that of Lower Rhineland, developed in the period of a warm climatic oscillation taking place in the Pannonian. That oscillation must have had a fairly large geographical extent, since it has been observed in the vegetation of Europe from its north-western part to the central part and must have been greatly warm, as the climatic conditions (see p. 11) favoured the luxuriant development of plants belonging to so many palaeotropical taxa.

In the light of the foregoing hypothesis, we may try to discuss the age of the mastixioidean flora in Lower Lusatia, the region neighbouring upon Lower Silesia. The fossil flora from the so-called Rauner Schichten, dated on the basis of the flora to the Middle Miocene, comes from several localities on the Klettwitzer Upland (Wischgrund, Wilhelminenglück, Schipkau and Klettwitz) and is considered to be the youngest Miocene flora in that area. In all the above-mentioned localities, Mai (1989) found numerous fruits and seeds of extinct and form genera (*Eoeuryale, Eomastixia, Epipremnites, Microdiptera* and *Sphenotheca)* and also palaeotropical ones (cf. Table 5). In his opinion (Mai 1989), the considerable proportion of the evergreen element of younger mastixioidean floras (among others, *Eomastixia* and *Sphenotheca)* points to the Middle Miocene age of the generally mesophilous-temperate flora.

The flora from Gozdnica has 28 genera in common with that from Lower Lusatia and 6 of them are palaeotropical (*Eomastixia, Epipremnites, Magnolia, Microdiptera, Symplocos* and *Sphenotheca*). The picture of plant communities is similar, mesophytic broad-leaved forest being the dominant forest community in both floras under comparison and in both of them the *Pinus-Sequoia-Fagus* trees play a significant role. As in Gozdnica, in the flora of Lower Lusatia the beech fruits differs from that of *Fagus decurrens* C. & E. M. Reid which are typical for the Neogene of Europe (*F. microcarpa* Miki *emend.* Uemura at Gozdnica and *F. deucalionis* Unger in Lusatia). The percentage of palaeotropical and arctotertiary elements as well as those of the exotic, native and extinct/form genera elements indicate that the flora from Lower Lusatia is more consistent with the Late Miocene floras from Gozdnica and Lower Rheinland even with the Early Pliocene flora from Ruszów than with the floras of the Middle Miocene (cf. Table 5). This conclusion agrees with Knobloch and Kvaček's (1976: 106) earlier suggestion concerning the younger, Pannonian age of the flora from Lower Lusatia.

The Pliocene flora of Lower Silesia points to a deterioration in climatic conditions, evidence for which is seen in the fossil flora from Ruszów (Hummel 1983, 1991; Baranowska-Zarzycka 1988). This last locality is situated near Gozdnica and the remains of its fruit-seed and leaf flora come from the same Gozdnica Series except that they belong to its younger, upper part (Fig. 3, profile 1/67). The fruit-seed flora from Ruszów is characterized by an 87.5% share of the arctotertiary element and 54.5% share of the native element (Table 5). The extinct/form genera *Aracispermum* Nikitn, *Epipremnites* and *Microdiptera*, and the taxa *Glyptrostrobus europaeus* (Brongn.) Unger, *Sparganium haentzscheli* Kirchh., *Nyssa ornithobroma* Unger, *Taxodium dubium* (Sternb.) Heer, *Magnolia cor* Ludwig and *Meliosma wetteraviensis* (Ludwig) Mai give the whole flora a distnict Tertiary aspect. In the landscape of these areas the wetland *Pinus-Sequoia-Fagus* forest flora from Gozdnica was replaced by rich deciduous broad-leaved forests of moderately humid biotopes with *Acer, Betula, Carpinus, Castanea* L., *Celtis* L., *Corylus* L., *Cornus* L., *Fagus, Fraxinus* L., *Liquidambar, Liriodendron* L., *Magnolia* L., *Meliosma* Blume, *Pyracantha* M. J. Roemer, *Phellodendron* Rupr., *Quercus* L., *Rubus, Sambucus* L., and *Weigela* Thunb. Wetland forest with *Taxodium, Glyptostrobus* Endl., *Nyssa, Myrica, Carya, Populus* L. and *Alnus* Miller was of minor importance to that flora and would indicate a conspicuous change in the water regime. The taxa it has in common with the Gozdnica flora are extraordinarily few in number. They are *Taxodium dubium, Carpinus* sp., *Betula longisquamosa* Mädler, *B. subpubescens, Microdiptera menzelii* (E. M. Reid) Mai [sub *Mneme menzelii* (E. M. Reid) Eyde], *Epipremnites reniculus* (Ludwig) Mai (sub *Epipremnum crassum* C. & E. M. Reid), *Dulichium marginatum* (C. & E. M. Reid) Dorof. and, in addition, a new species of maple, *Acer pseudodiabolicum* Baranowska-Zarzycka, so far described only from Ruszów.

SUMMARY OF RESULTS

(S. DYJOR, A. SADOWSKA AND E. ZASTAWNIAK)

The complete formation of the Neogene deposits within the south-western marginal part of the Tertiary basin of the Polish Lowland, with numerous palynological profiles and well-preserved plant remains, permitted the dating of the rock series of that period and the determination of the environment of their origin. These sediments were deposited in brackish, lacustrine, marshy and alluvial environments and often contain pollen material and plant macrofossils. Although the thickness of particular series is reduced in the central part of the basin, they are characterized by the continuity of sedimentation. Consequently, it was possible to elaborate the lithostratigraphical and palynological standard profile for the Badenian-Pliocene period on this basis and, in conjunction with the determinations of the macroflora, to reconstruct the climatic and palaeogeographical changes occurring in the region of south-western Poland in the Younger Tertiary.

The profiles from the upper part of the Mużaków series reflect the vanishing of the sea basin and is connected with the Lower-Badenian Langenfeld transgression. Above it there was a sedimentary transition to peat-swamp layers and this gave rise to the Brown-coal seam Henryk (Lusatian series I). The pollen spectra from the sediments of the Mużaków Series are dominated by plant communities that existed at shorter or longer distances from the shore of the water basin and contain a high proportion of coniferous trees. The presence of marine micro-organisms points to the salinity of the water basin.

Additionally, the Brown-coal seam Henryk was formed from the vegetation of bush swamps and swamp forests rich in species. The picture of the fossil flora from these deposits differs only facially from the vegetation of the Mużaków Series, whereas stratigraphically it is similar to and characteristic of the Late Badenian formations. The formation of the peat layers which later formed the coal of the Henryk seam was followed by a fresh depression in the land and the development of a water basin. In this seam the accumulation of coal clays with a flora from the Grey Clay Horizon, the lower member of the Poznań Series, took place. A swamp forest also grew on the shore of that basin, as evidenced by sporomorphs and abundant impressions of leafy twigs and cones of *Glyptostrobus europaeus* (Brongn.) Unger and shoots of *Taxodium dubium* (Sternb.) Heer found in the Grey Clay Horizon at Mirostowice (Sadowska 1977; Zastawniak 1978). These conifers were accompanied by some deciduous trees of the genera *Populus* and *Salix*. In the vicinity there also grew trees of the genera *Acer, Fraxinus* and *Phellodendron, Photina* shrubs and climbers of *Periploca* and *Vitis*.

Afterwords, the Poznań Series basin underwent a deepening and the Green Clay Horizon (with glauconite) was deposited in it. The presence of glauconite and a poor, devastated, marine microfauna makes it possible to correlate them with the central part of the Poznań Series basin, in which marine sediments, dated on the basis of their fauna to the Late Badenian, were found (Łuczkowska & Dyjor 1971). These layers may be correlated with the Grabowiec beds from the Silesian part of the Carpathian Foredeep (Dyjor & Sadowska 1986a).

The top layers of the Green Clay Horizon and the lower part of the Flamy Clay Horizon of the Poznań Series are already devoid of any traces of marine influence. They were formed in an extensive shallow lake, probably as early as the Sarmatian, as is indicated by the results of geological and palynological studies of analogous deposits from the Fore-Sudetic part of the Paratethys bay (Dyjor & Sadowska 1984, 1986a; Sadowska 1989). This is also suggested by the pollen flora of the profile obtained from the top part of the Flamy Clay Horizon in the Gozdnica-Stanisław outcrop (Fig. 3, profile 4/71; pollen diagram in Stachurska *et al.* 1971, Fig. 4, profile 3). It proves that the role of swamp plants diminished in the forest communities of that area; the vegetation, however, still abounded in numeous thermophilous taxa and it was of a distinctly Miocene nature. This flora indicates not only the age of the deposits in question but also the time of the termination of sedimentation of the Poznań Series in this region of Poland.

In the course of the shallowing and vanishing of the Poznań Series basin there were short-lived breaks in sedimentation and the upper deposits of this series were eroded. In the shallow incised palaeochannels of rivers, the sedimentation of the Gozdnica Series began. These were mainly silty-sandy and clayey deposits and contain numerous remains of macro- and microfloras. That period is dated by the palynological profiles from the outcrop at Gozdnica (Fig. 3, profile 3/71; pollen diagram in Stachurska *et al.* 1971, Fig. 5) with its fruits-seed flora and with the fruit-seed flora, leaf compressions and impressions and wood from Gozdnica-Stanisław (profile 2). The pollen flora from these profiles shows the domination of mixed and decidous forests overgrowing moderately wet and rather dry habitats. The proportion of swamp communities in the palynological picture is reduced, however, in the macroscopic flora it is still abundant with numerous characteristic components, namely, *Taxodium, Nyssa, Proserpinaca* and *Aldrovanda*. Geological studies show the formation of morphologically differentiated alluvial fans, deposited here by the Sudetic rivers. This area was overgrown by luxuriant mixed forests with the dominant tree genera *Pinus, Sequoia* and *Fagus* and with high percentages of the arctotertiary (67%) and native (46%) elements, but also with a very high proportion of the palaeotropical element (33%) and that of the extinct element (12%). The presence of components of the so-called younger mastixioidean flora sensu Mai (1965a) (the genera *Eomastixia, Eurya, Magnolia, Mastixia, Sphenotheca, Symplocos, Styrax, Tectocarya* and *Tetrastigma*) in the Gozdnica flora is its peculiar feature. The occurrence of mastixioidean remains in the deposits younger than the Sarmatian proves that the vegetation of those times developed in a period of warm climatic oscillation, which must have taken place in the Pannonian. No doubt, it was very significant and had a large geographical extent as the presence of mastixioidean remains can be also seen in the vegetation of that time in Lower Lusatia (Mai 1989) and Rhineland (Van der Burgh 1987).

The results obtained provide evidence for the formation of the Gozdnica Series in the area in question as early as the upmost Miocene, probably in the Pannonian-Pontian period. Such an early decline for the sedimentation of the Poznań Series in the Gozdnica region is connected with its situation in the marginal part of the basin and in an area of tectonic activity, which was active during the Valachian phase and uplifted the Sudetes and the Foresudetic block.

The character of the plant communities of the south-western Poland in the latest Miocene indicates of warm temperate and wet climate and there are no reasons to assume drying of climate in this period.

Such climatic drying is connected with the so-called messinian crisis which took place in the Mediterranean Basin.

The higher-lying components of the Gozdnica Series in this area are dated by the palynological profile from Ruszów (Stachurska *et al.* 1967) and the leaf flora (Hummel 1983, 1991) and fruit-seed flora (Baranowska-Zarzycka 1988) from that locality. The pollen flora has a much younger appearance in comparison with the above-discussed profiles of this series from Gozdnica. It suggests the presence of swamp forests, which differ in composition with the swamp forests in the Badenian and Sarmatian in which alder predominates, and the presence of mesophilous deciduous forests with an admixture of conifers and a high proportion of herbaceous plants. The number of warmth-demanding taxa is small in these communities, the plants of the temperate climate being dominant, and this factor finds expression in the conspicuous proportion of the arctotertiary element (above 87%) in the macroflora. The pollen, leaf and fruit-seed flora from Ruszów reflect the communities of rich deciduous forests of moderately damp biotopes, growing in temperate and warm-temperate climates, as well as the communities of water and swamp vegetation. The extinct genera *Microdiptera, Epipremnites* and *Aracispermum* and plants from the genera *Glyptostrobus, Nyssa, Taxodium, Magnolia* and *Meliosma*, characteristic of the Tertiary, were still present in these communities. The general picture of vegetation, however, provides evidence for the distinct cooling (but not drying) of the climate. It is also confirmed by the results of geological studies indicating a rise in the precipitation in the mountains, activation of erosion and intense alluvial sedimentation within the range of alluvial foreland fans.

The age of the palynological profile from Ruszów has been established at the upper part of the Early Pliocene.

The palaeobotanically documented youngest members of the Gozdnica Series, which might be referred to the Late Pliocene, are however absent from the area under study. The reduction of the processes of chemical weathering in the arkosic deposits of this series indicates a marked cooling of the climate but, so far, there are no localities with fossil flora known from these deposits in the Gozdnica region. The highest Gozdnica Series members of Late Pliocene age were found and dated only at Kłodzko (Jahn *et al.* 1984). The flora of that locality points at a distinct cooling and is documented by a considerable rise in the proportion of conifers, especially spruce, an increase in the role of herbs and the distinct predominance of Quaternary over Tertiary taxa.

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Received 07 August 1992

Plates

Plate 1

Pinus (*Pinus*) cf. *brevis* Ludwig

1. Seed with a fragment of wing, x 16, Gozdnica-Stanisław, No. 83/275
2. Seed, x 10, Gozdnica-Stanisław, No. 83/155–2
3. Seed, x 5, Gozdnica-Stanisław, No. 83/155–1
4. Fragmentary cone scale, x 5, Gozdnica-Stanisław, No. 83/155–2
5. Stomata of a leaf, x 500, Gozdnica-Stanisław, No. 83/101–1
6. Fragmentary leaf fascicle, x 10, Gozdnica-Stanisław, No. 83/165
7. Fragmentary leaf fascicle with two needle leaves, x 5, Gozdnica-Stanisław, *s.n.*

Pinus (*Pinus*) cf. *spinosa* Herbst

8. Seed, x 13, Gozdnica-Stanisław, No. 83/277
9. Seed, x 10, Gozdnica-Stanisław, No. 83/167
10. Fragmentary leaf fascicle, x 10, Gozdnica-Stanisław, No. 83/166
11. Fragmentary leaf fascicle, x 10, Gozdnica-Stanisław, No. 83/168
12. Fragment of juvenile cone, x 5, Gozdnica, No. 83/12
13. Stoma of a needle fragment, x 500, Gozdnica, No. 83/12–1

1, 8 photo by A. Pachoński
2–4, 6, 7, 9–12 photo by J. Brožek
5, 13 photo by Z. Kvaček

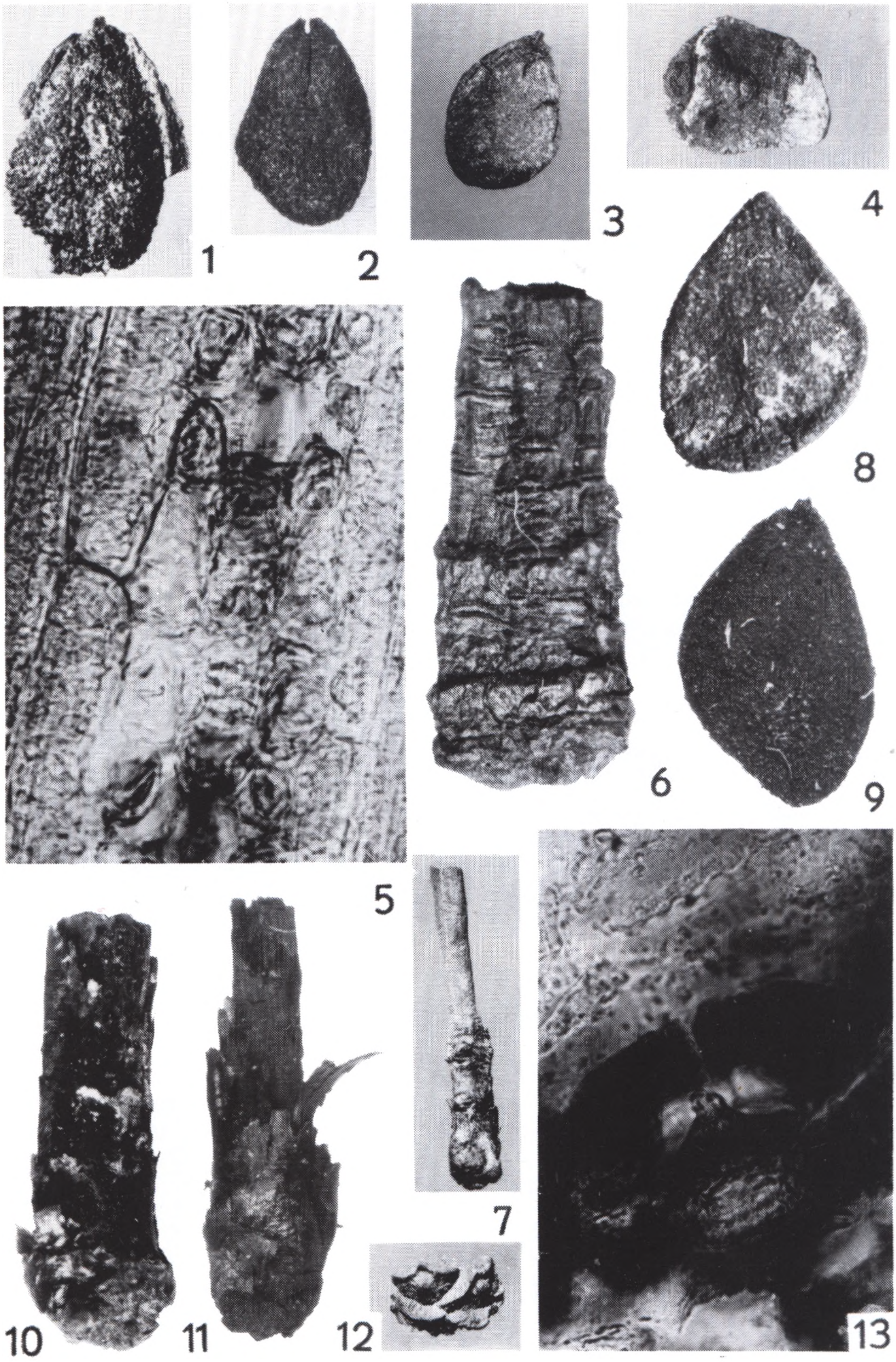
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Plate 2

Pinus (*Strobus*) *leitzii* Kirchh.

1. Fragmentary fascicle with needle leaves, x 5, Gozdnica-Stanisław, No. 83/137–1
2. Leaf tip, x 5, Gozdnica-Stanisław, No. 83/137–1
3. Fragmentary fascicle with needle leaves, x 5, Gozdnica-Stanisław, No. 83/137–1
4. Leaf cuticle with a stomatal row, x 200, Gozdnica-Stanisław, *s.n.*
5. Teeth on leaf margin, x 80, Gozdnica-Stanisław, *s.n.*

6, 7. *Pinus haploxylon* type sensu Rudolph, pollen *in situ*, x 500, Gozdnica, No. 83/11–1

8, 9. Male cones, x 5, Gozdnica, No. 83/10–1

? Pinaceae gen. et sp. indet.

10. Brachyblast, x 5, Gozdnica-Stanisław, No. 83/97–1

Tsuga (sect. *Tsuga*) sp.

11. Fragment of basal part of a leaf, x 10, Gozdnica-Stanisław, No. 83/156
12. Abaxial cuticle (phase contrast), x 200, Gozdnica-Stanisław, No. 83/162

1–3, 8–11 photo by J. Brožek
4–7, 12 photo by Z. Kvaček

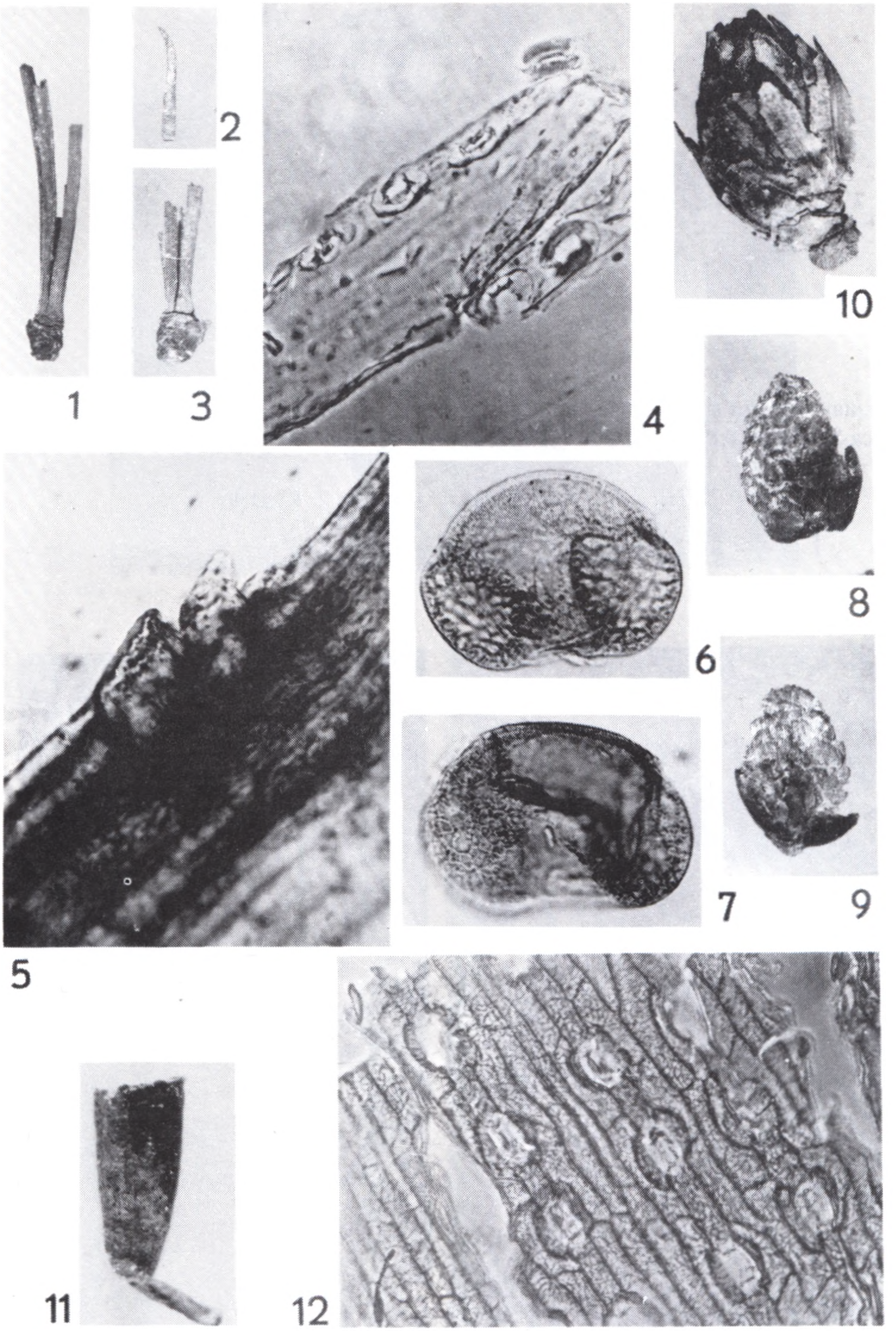
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Plate 3

Pollen grains of *Pinus haploxylon* type sensu Rudolph *in situ* in male cone of *Pinus leitzii* Kirchh. from Gozdnica-Stanisław. All figures SEM (1, 3 – x 1500, 2 – x 300)

photo by Z. Kvaček

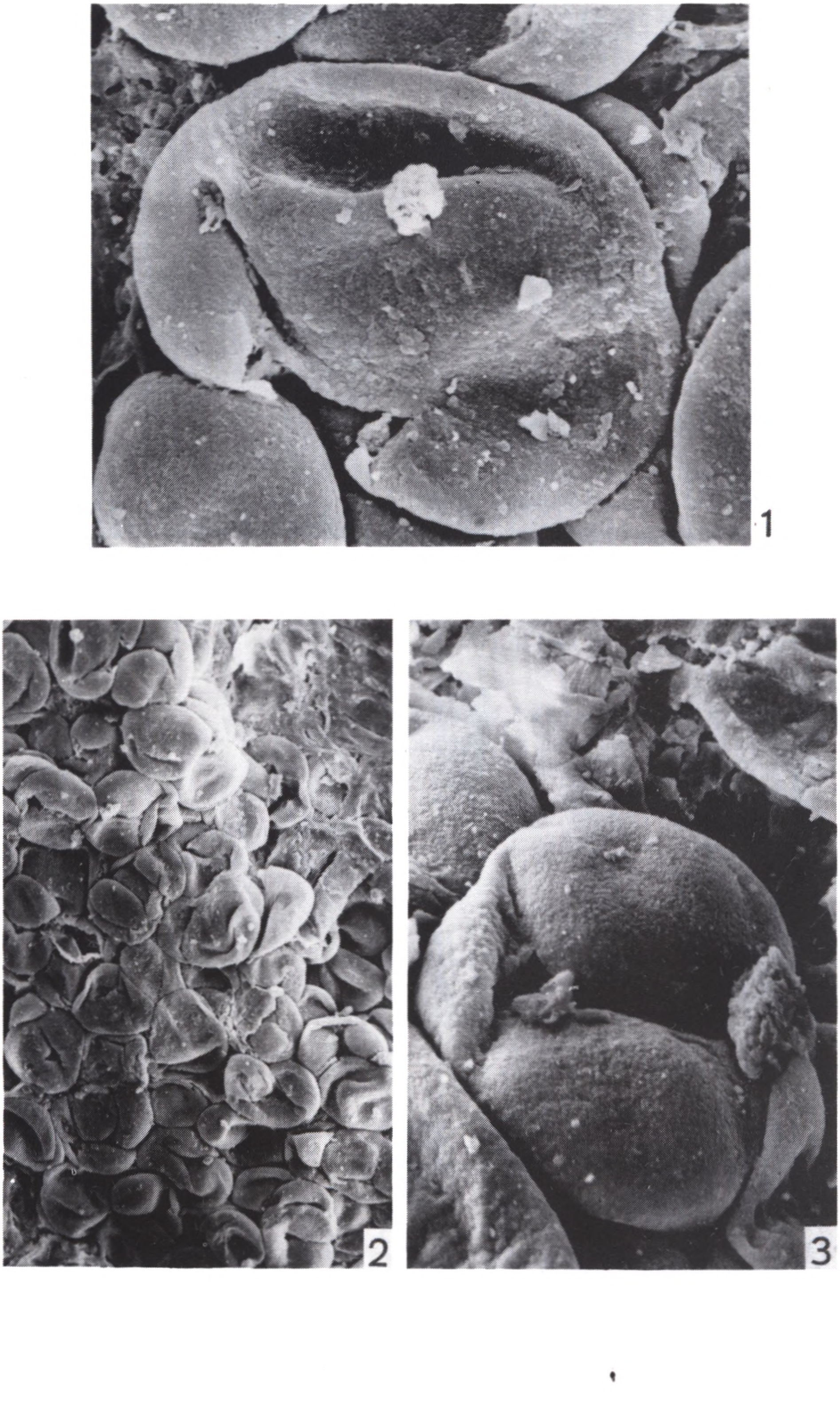
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Plate 4

Sequoia abietina (Brongn.) Knobloch

1. 'taxodioid' twig, x 1.5, Gozdnica-Stanisław, *s.n.*
2. 'taxodioid' twig, x 1, Gozdnica-Stanisław, No. 83/123
3. 'cupressoid' twig, x 5, Gozdnica, No. 83/315
4. 'cryptomerioid' twig, x 5, Gozdnica, No. 83/16–1

5, 6. *Sequoiapollenites polymorphosus* Thierg. type, pollen *in situ* obtained from the male cone of *Sequoia abietina* (Brongn.) Knobloch shown in Fig. 7, x 500, Gozdnica, No. 83/15–1/1

7. Male cone, x 5, Gozdnica, No. 83/15–1
8. tip of 'cupressoid' twig, x 5, 8 a – x 10; Gozdnica-Stanisław, No. 83/147–1

9, 10. Seeds, x 5, Gozdnica, No. 83/4–1

Taxodium dubium (Sternberg) Heer

11. Fragmentary 'taxodioid' twig, x 5, Gozdnica, No. 83/56–1
12. Fragmentary 'cupressoid' twig, x 5, Gozdnica, No. 83/56–2
13. Seed, x 5, Gozdnica, No. 83/54–1

1–4 photo by J. Brožek
5, 6 photo by Z. Kvaček

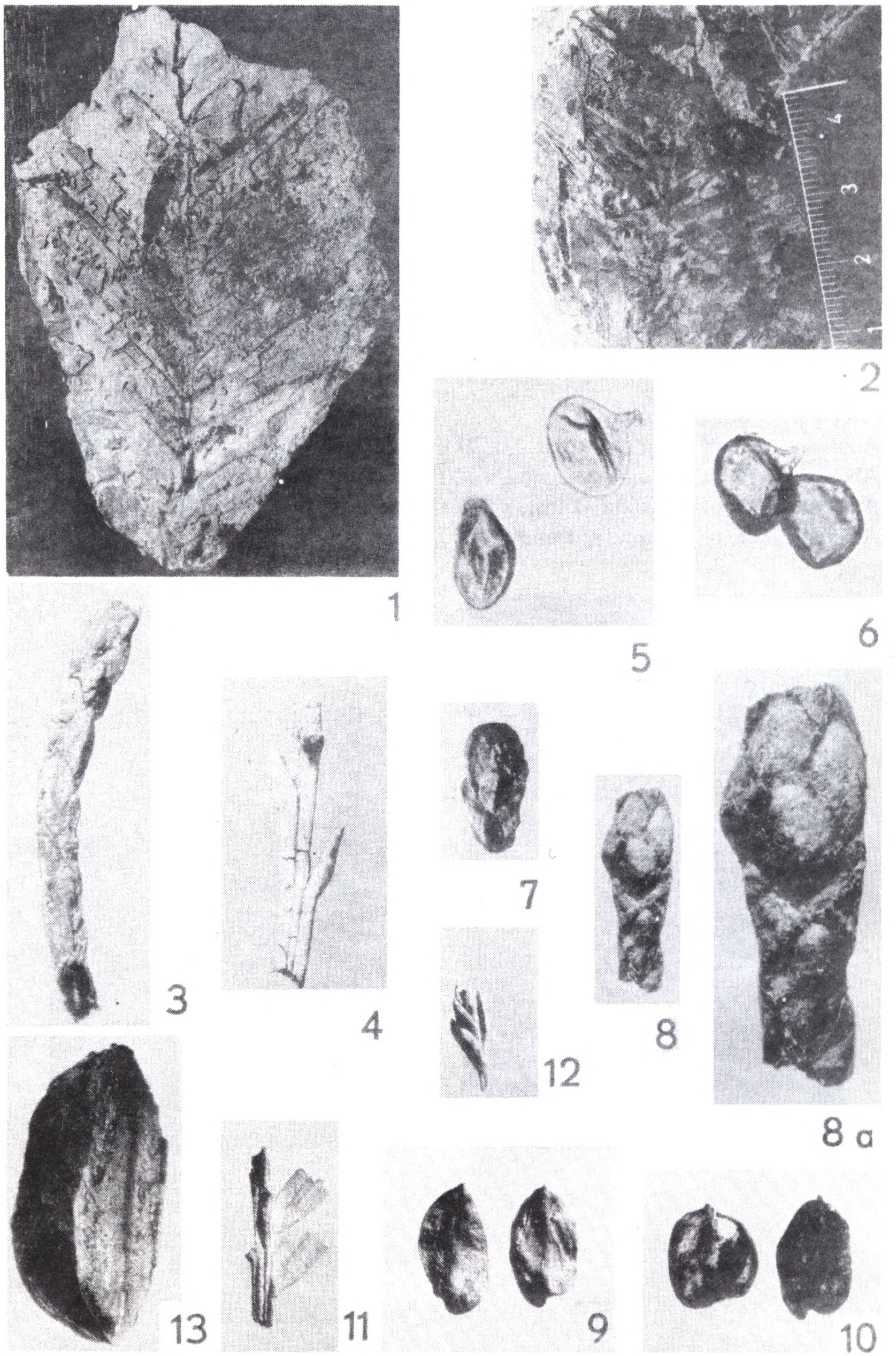
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Plate 5

Sequoia abietina (Brongn.) Knobloch

1. Adaxial cuticle of a 'cupressoid' leaf, x 200, Gozdnica-Stanisław No. 83/147–1/1
2. Abaxial cuticle of the same specimen, x 200
3. Adaxial cuticle of a 'taxodioid' leaf, x 500, Gozdnica-Stanisław No. 83/123–1
4. Abaxial cuticle of the same specimen, x 500

photo by Z. Kvaček

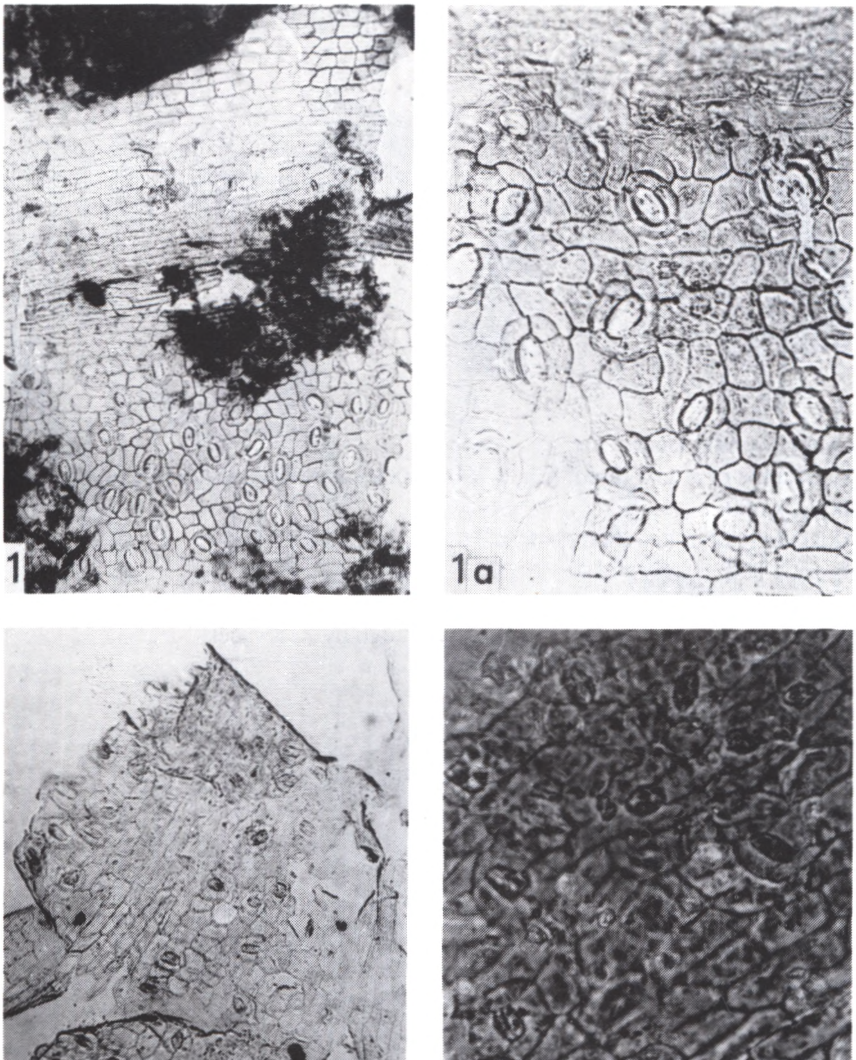
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Plate 6

Taxodium dubium (Sternb.) Heer

1. Abaxial cuticle of a 'taxodioid' leaf, x 200, Gozdnica-Stanisław, No. 83/140–1

1a. As above, x 500

2. Abaxial cuticle of a 'taxodiod' leaf, x 200, Gozdnica, No. 83/56–1

2a. As above, x 500

photo by Z. Kvaček

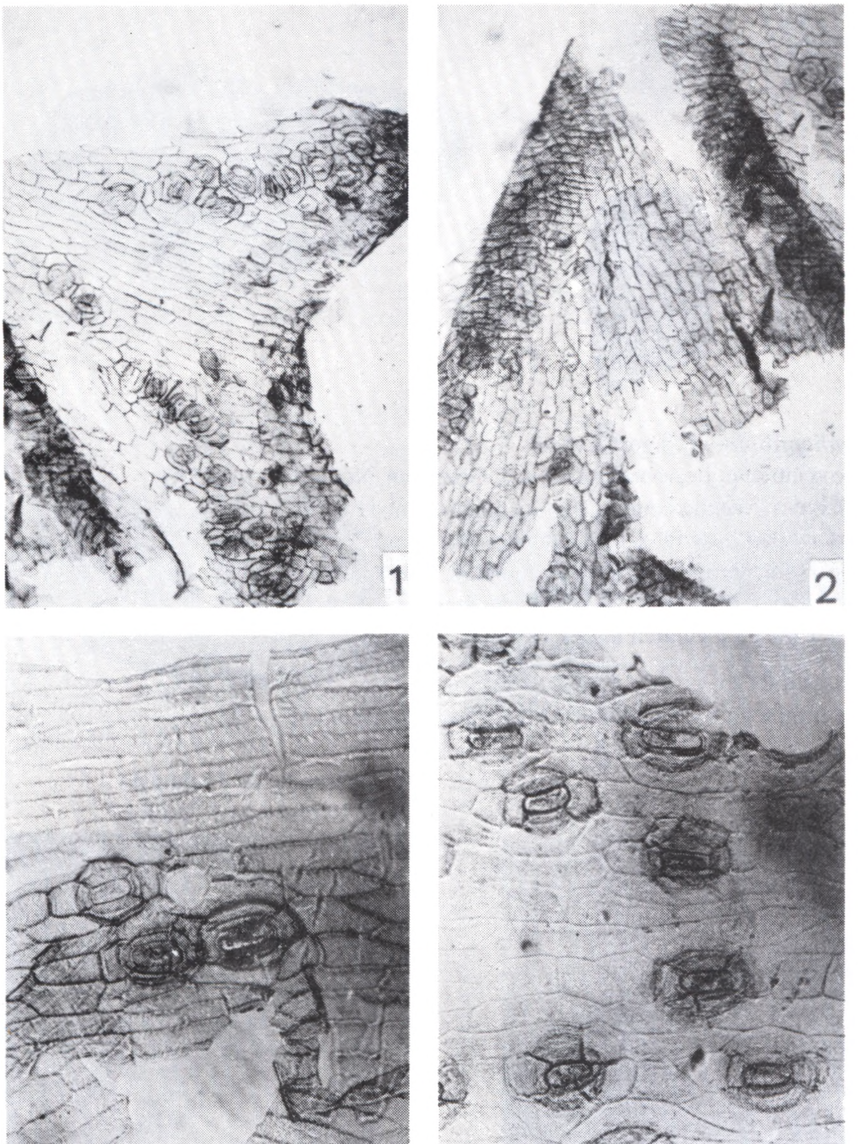
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Plate 7

Tetraclinis salicornioides (Unger) Kvaček

1, 2. Cone scale seen from both sides, x 7, Gozdnica, No. 6564p MGUWr
3, 4. Scales of a juvenile cone, x 10, Gozdnica-Stanisław, *s.n.*
5. Terminal part of twig, x 10, Gozdnica-Stanisław, No. 83/169
6. Twig fragment, x 10, Gozdnica-Stanisław, No. 83/143–2
7. Terminal part of twig, x 10, Gozdnica-Stanisław, No. 83/169
8, 9 Cuticle of the specimen in Fig. 6, x 500

Cupressaceae gen. et sp.

10. Twig fragment, x 10, Gozdnica-Stanisław, No. 83/143–1

1, 2 photo by A. Pachoński
3–7, 10 photo by J. Brożek
8, 9 photo by Z. Kvaček

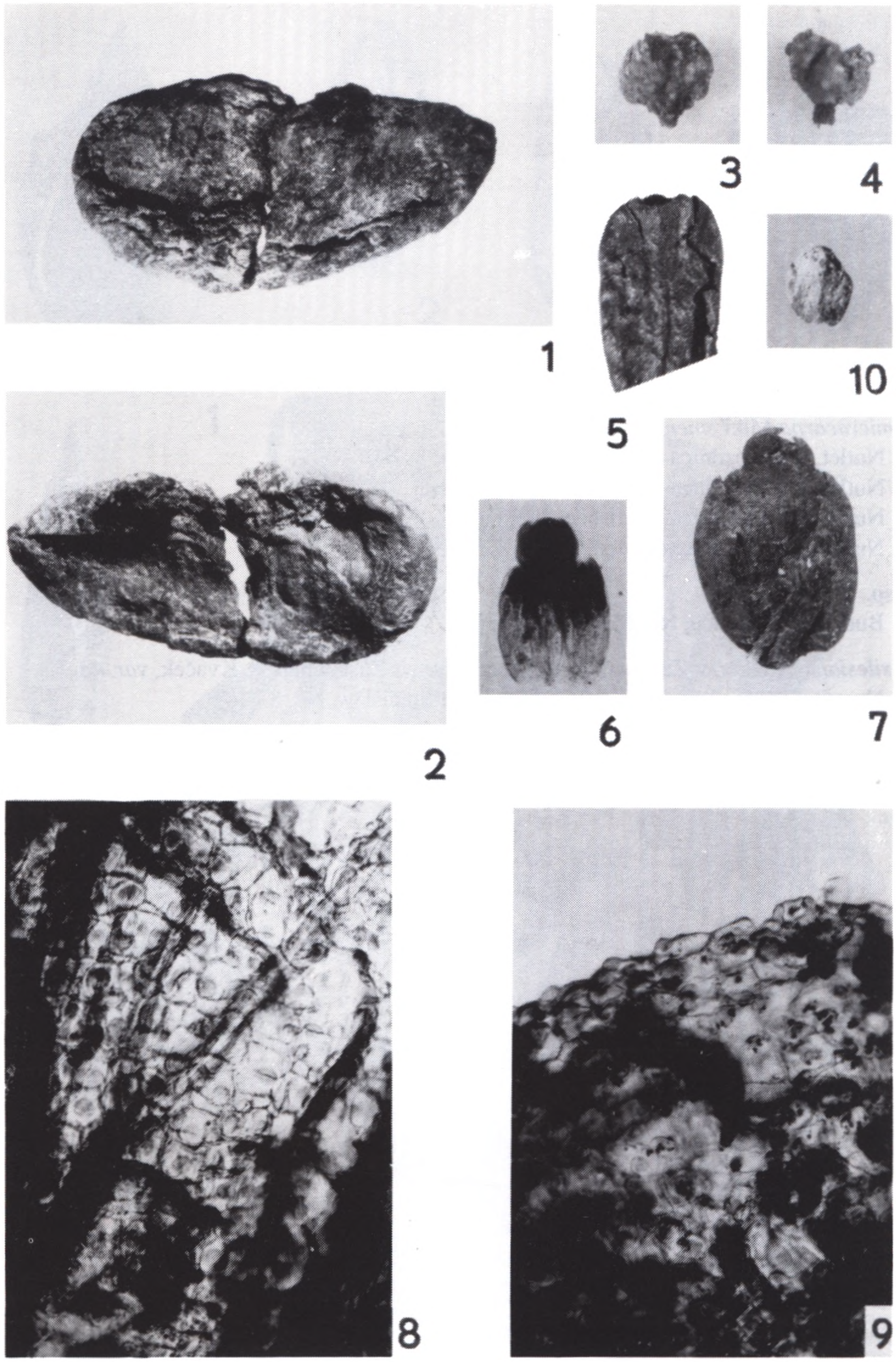

Plate 8

Fagus microcarpa Miki *emend.* Uemura

1. Nutlet, x 4, Gozdnica-Stanisław, No. 83/266
2. Nutlet, x 5, Gozdnica-Stanisław, No. 83/267
3. Nutlet, x 4, Gozdnica-Stanisław, No. 83/267
4. Nutlet, x 5, Gozdnica-Stanisław, No. 83/266

Fagus sp.

5. Bud, x 4, Gozdnica, No. 6560 MGUWr

Fagus silesiaca Walther & Zastawniak var. ***gozdnicensis*** Zastawniak & Kvaček, *var. nov.*

6. Numerous leaf compressions, x 1, Gozdnica-Stanisław, No. 83/102

photo by A. Pachoński

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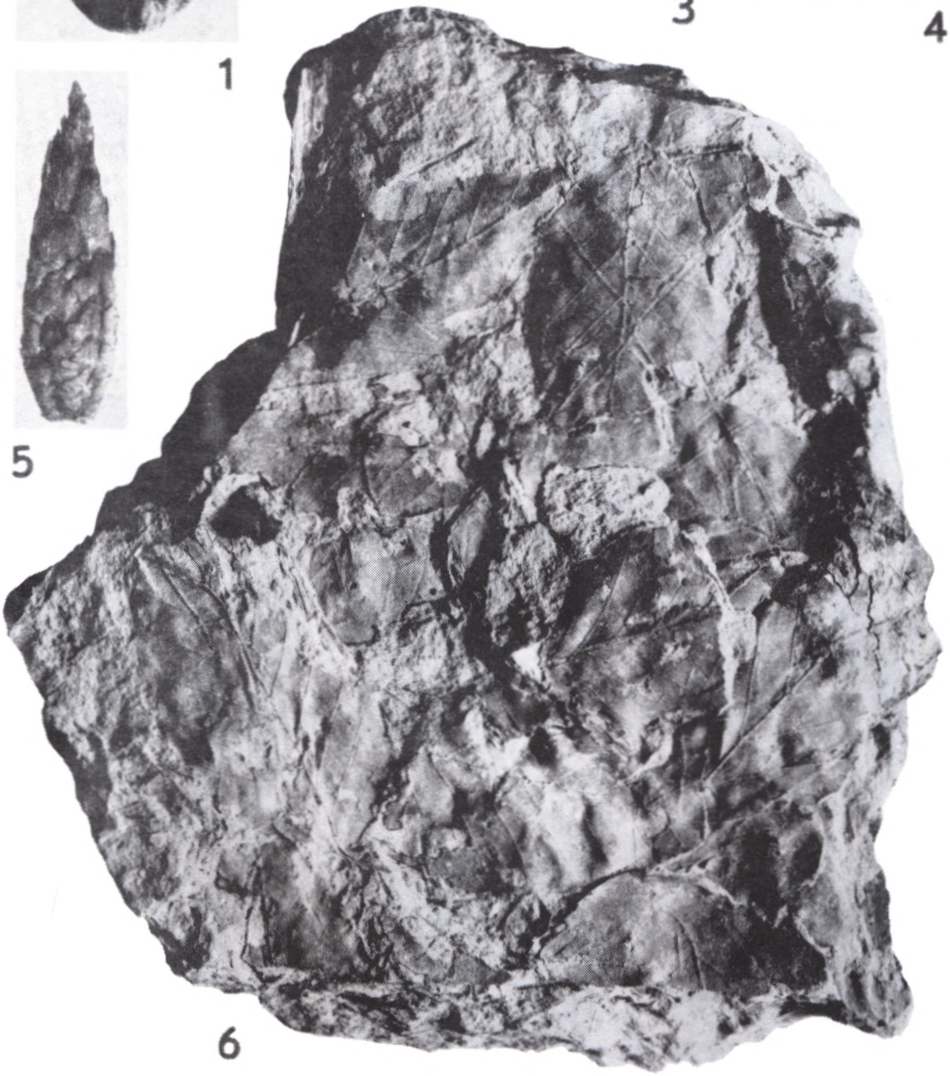

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Plate 9

Fagus microcarpa Miki *emend.* Uemura

1. Cupula, x 4, Gozdnica-Stanisław, No. 83/265
2. Cupula, x 4, Gozdnica-Stanisław, No. 83/264

Fagus silesiaca Walther & Zastawniak var. ***gozdnicensis*** Zastawniak & Kvaček, *var. nov.*

3. Holotype, leaf compression, x 1.5, Gozdnica-Stanisław, No. 83/99
4. Isotype, with the nutlet of *Fagus microcarpa* Miki *emend.* Uemura on the surface, x 1, Gozdnica-Stanisław, No. 83/117

Liquidambar sp.

5, 6. Abortive seeds, x 24 Gozdnica, No. 83/49–1

cf. *Stellaria* sp.

7. Seed, x 25, Gozdnica-Stanisław, No. 83/288a

cf. *Ceratophyllum* sp.

8, 9. Fragement of fruit seen from both sides, x 11, Gozdnica-Stanisław, No. 83/251

photo by A. Pachoński

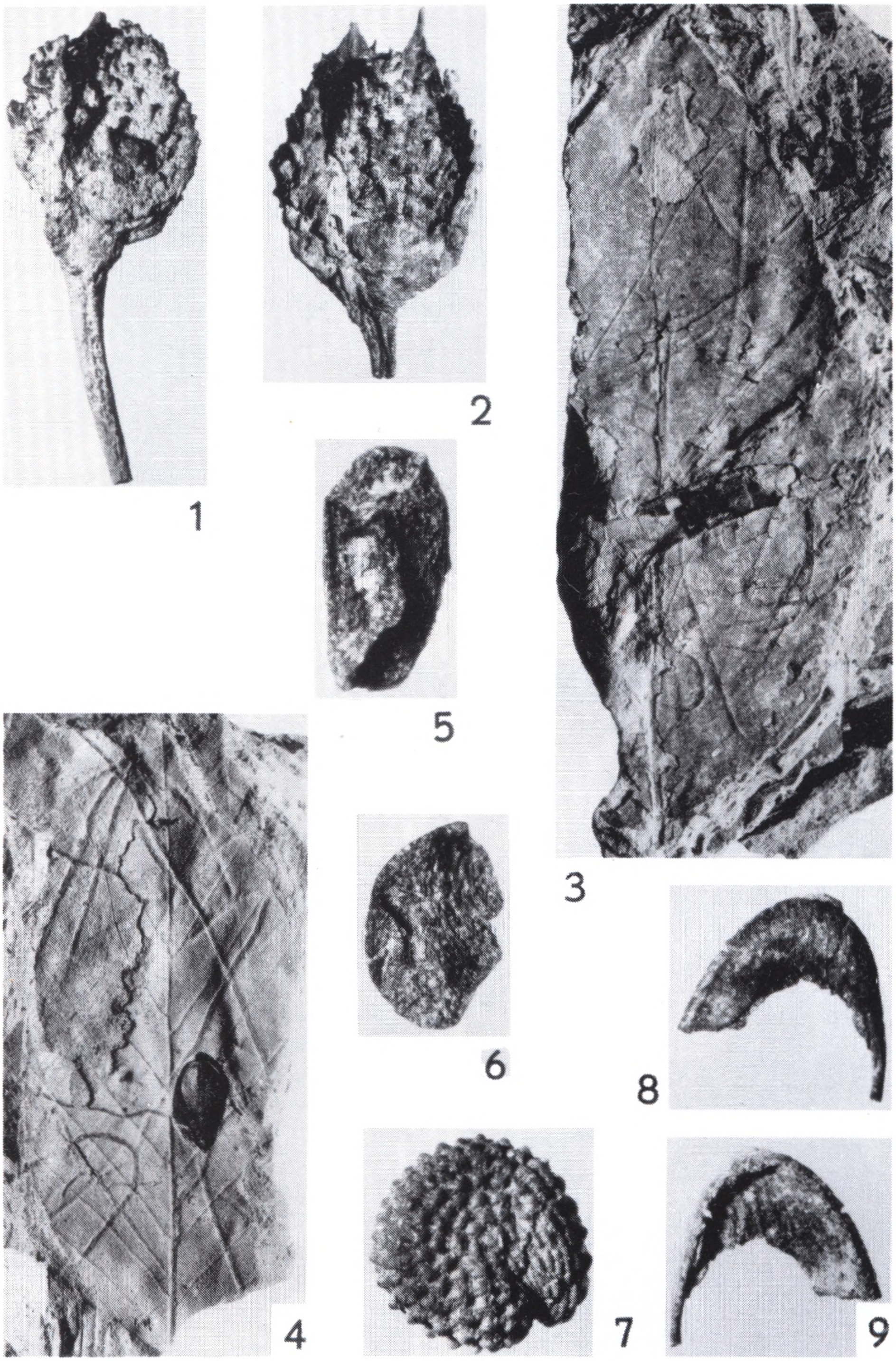
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Plate 10

Faguspollenites verus Raatz type from Gozdnica-Stanisław. All figures SEM (1 – x 1500, 2 – fragment of sculpture of surface, x 5000, 3 – x 100)

photo by Z. Kvaček


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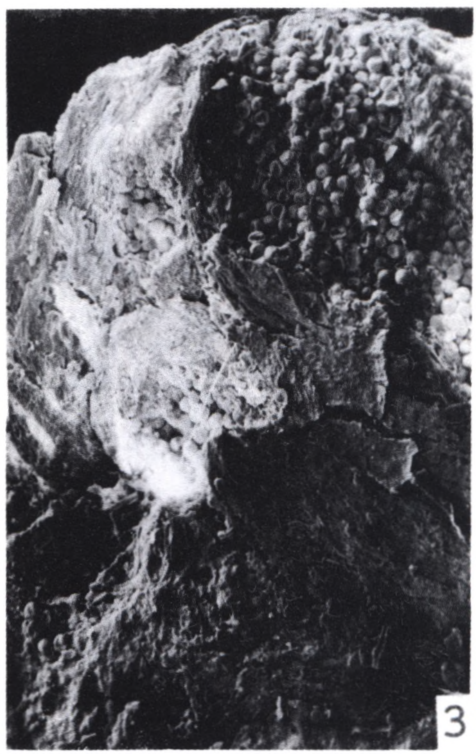
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Plate 11

Betula subpubescens Goepp.

1. Fragmentary leaf compression, x 1, Gozdnica-Stanisław, No. 83/111

1a. Enlarged margin of the same leaf, x 10

Fagus silesiaca Walther & Zastawniak var. ***gozdnicensis*** Zastawniak & Kvaček, *var. nov.*

2. Leaf compression and pine leaf fragments (*Pinus leitzii* Kirchh. and *Pinus* cf. *brevis* Ludwig) on the left side, x 1, Gozdnica-Stanisław, No. 83/101
3. Leaf compression, x 1, Gozdnica-Stanisław, No. 83/136
4. Leaf compression, x 1, Gozdnica-Stanisław, No. 83/105

photo by J. Brożek

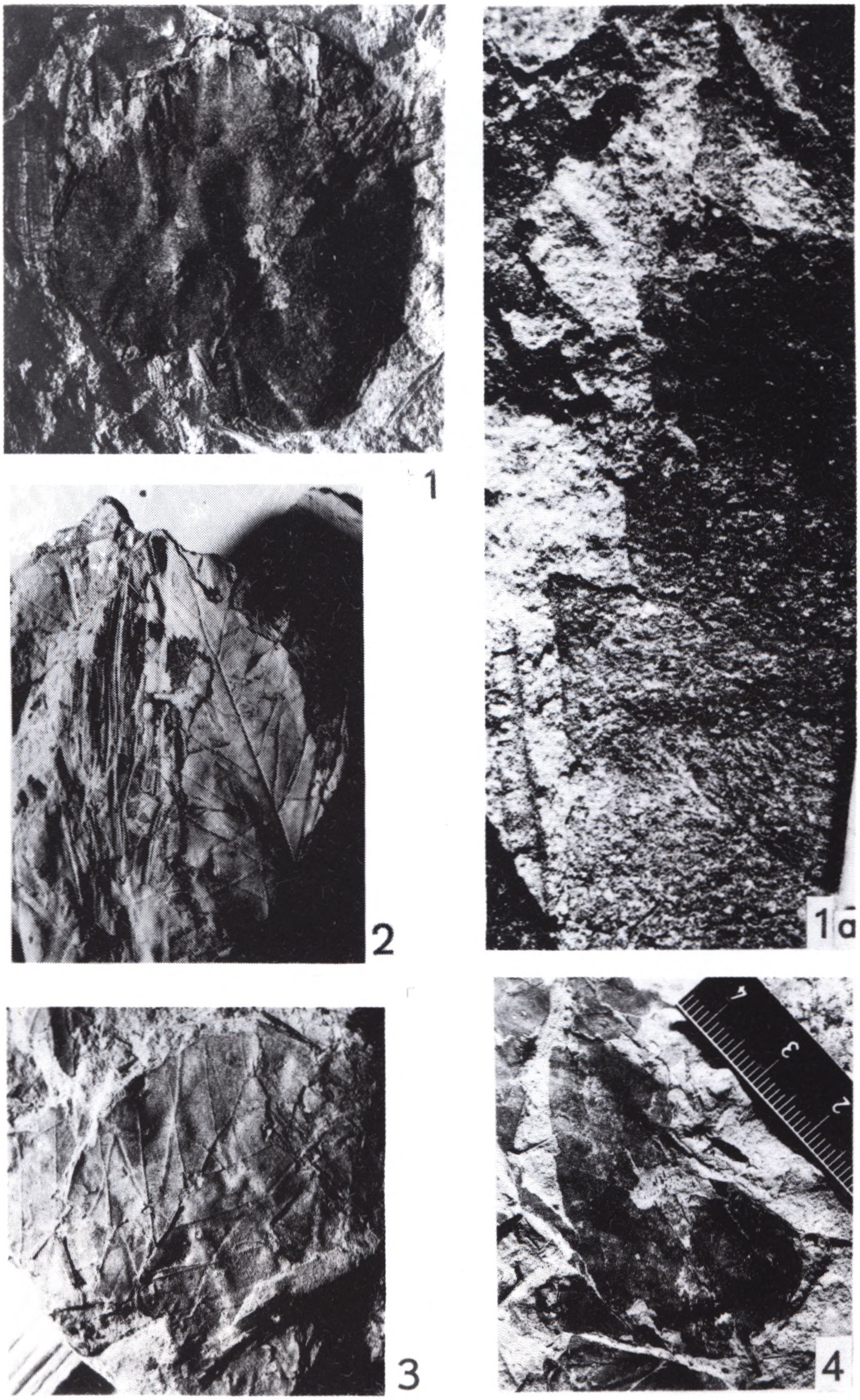
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Plate 12

Fagus silesiaca Walther & Zastawniak var. ***gozdnicensis*** Zastawiak & Kvaček, *var. nov.*

1. Hairs in the axille of secondary vein, x 80, Gozdnica-Stanisław, No. 83/99–1
2. Adaxial cuticle, the same preparation, x 500
3. Abaxial epiermis with stomata and bases of glandular trichomes, x 500, Gozdnica-Stanisław, No. 83/99–1
4. Abaxial epidermis with stomata and bases of glandular trichomes, x 500, No. 83/136–1

photo by Z. Kvaček

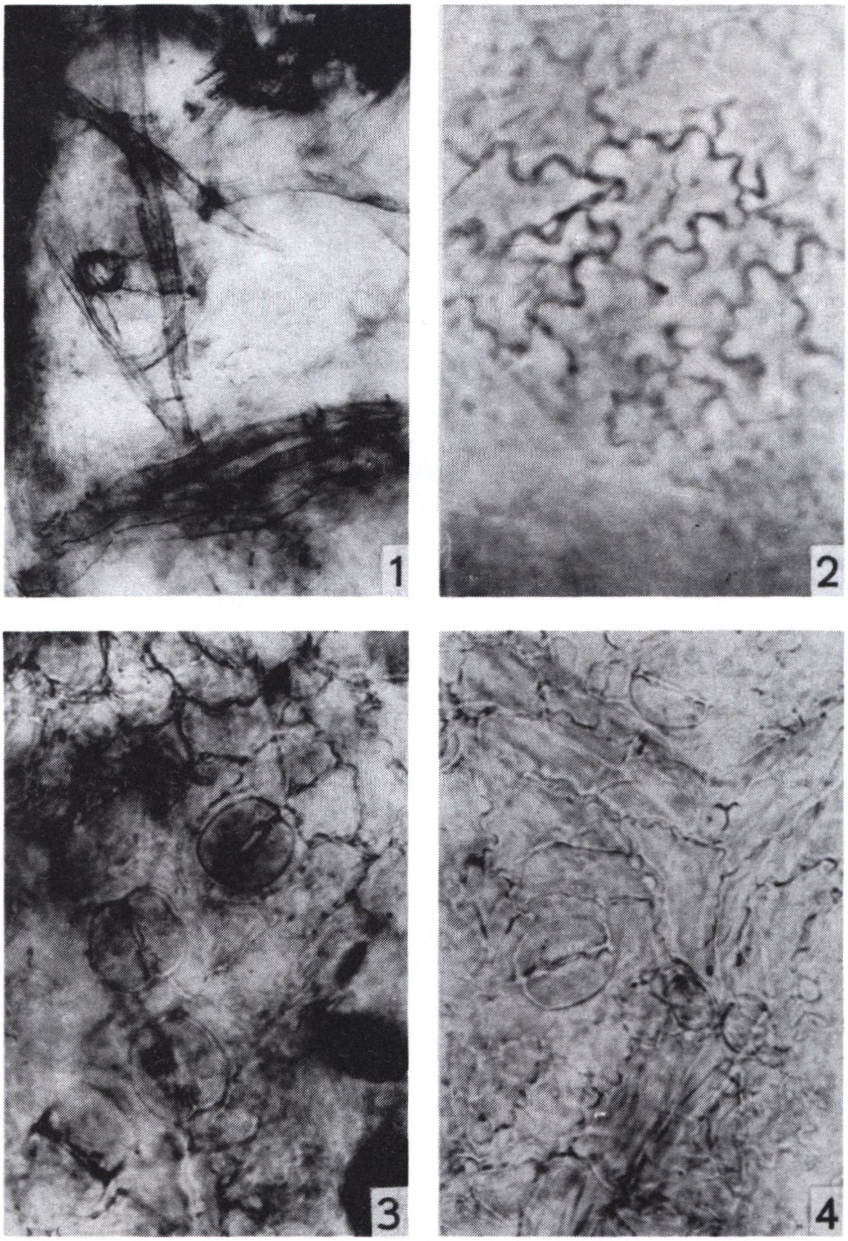
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Plate 13

Leaves and fruits of *Fagus pashanica* C. C. Yang from the Institute of Botany, Academia Sinica, Beijing, China and according to the author of species, a synonim of *Fagus hayatae* Palibin *ex* Hayata.

Photo by courtessy of Dr. Li Hao-min, Nanjing Institute of Geology and Palaeontology, Academia Sinica, Nanjing, People's Republic of China


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Plate 14

Betula subpubescens Goepp.

1. Abaxial cuticle, x 200, Gozdnica-Stanisław, No. 83/111–1

2, 3 Stomata in abaxial cuticle, same preparation, x 500

4. A base of the glandular hair, same preparation, x 500

photo by Z. Kvaček

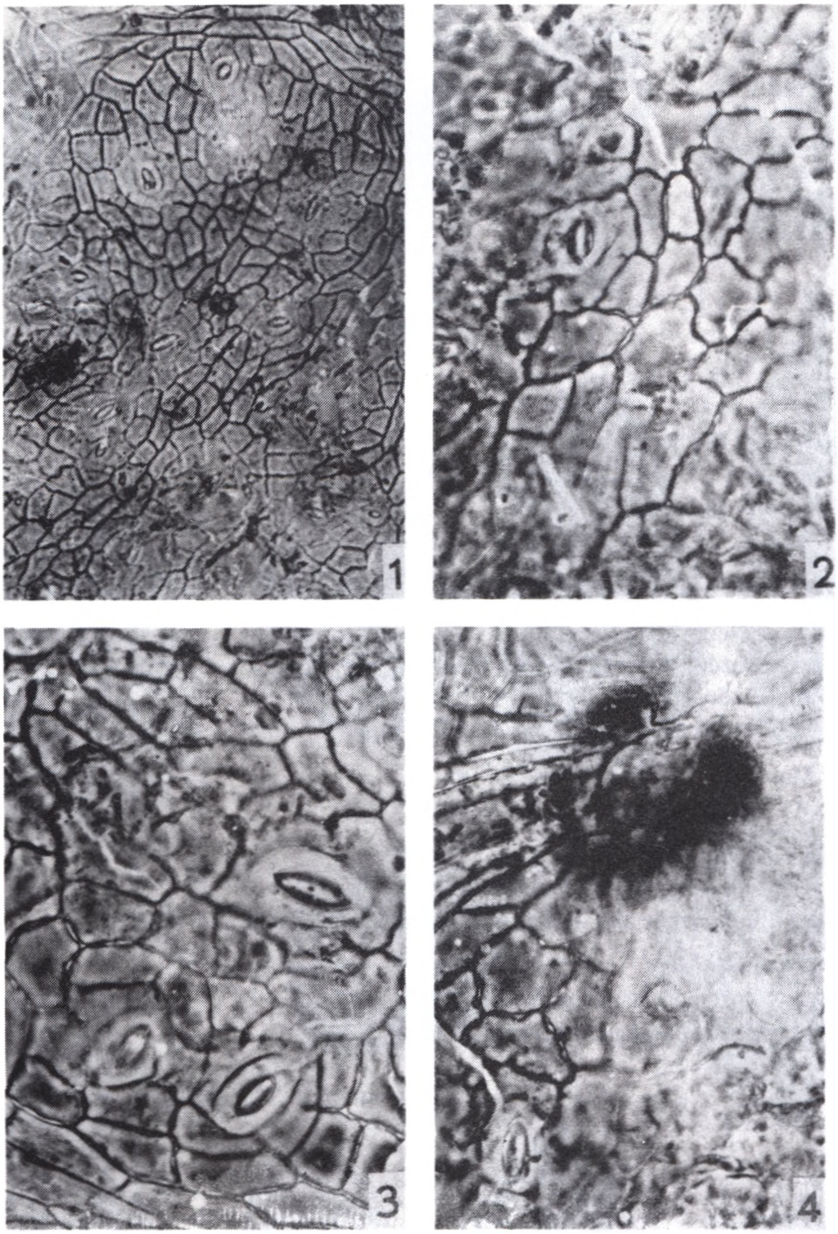
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Plate 15

Betula longisquamosa Mädler
1. Nut with wing, x 12, Gozdnica, No. 83/290
2. Nut, x 13, Gozdnica, No. 83/290

cf. *Betula* sp.
3. Fruiting catkin, x 7, Gozdnica, No. 83/289

Carpinus moldavica Negru
4, 5. Nuts, x 12, Gozdnica-Stanisław, No. 83/249
6. Nut, x 10, Gozdnica-Stanisław, No. 83/250
7. Nut, x 11, Gozdnica-Stanisław, No. 83/179

Ostrya szaferi Mai
8, 9. Nuts, x 11, Gozdnica-Stanisław, No. 83/273

Eurya stigmosa (Ludwig) Mai
10. Seed, x 12, Gozdnica, No. 6559p MGUWr
11, 12. Seed seen from outside and inside, x 17, Gozdnica-Stanisław, No. 83/263

Myrica ceriferiformis Kownas
13. Fruit, x 14, Gozdnica-Stanisław, No. 83/272
14. Fruit, x 13, Gozdnica-Stanisław, No. 83/272

photo by A. Pachoński

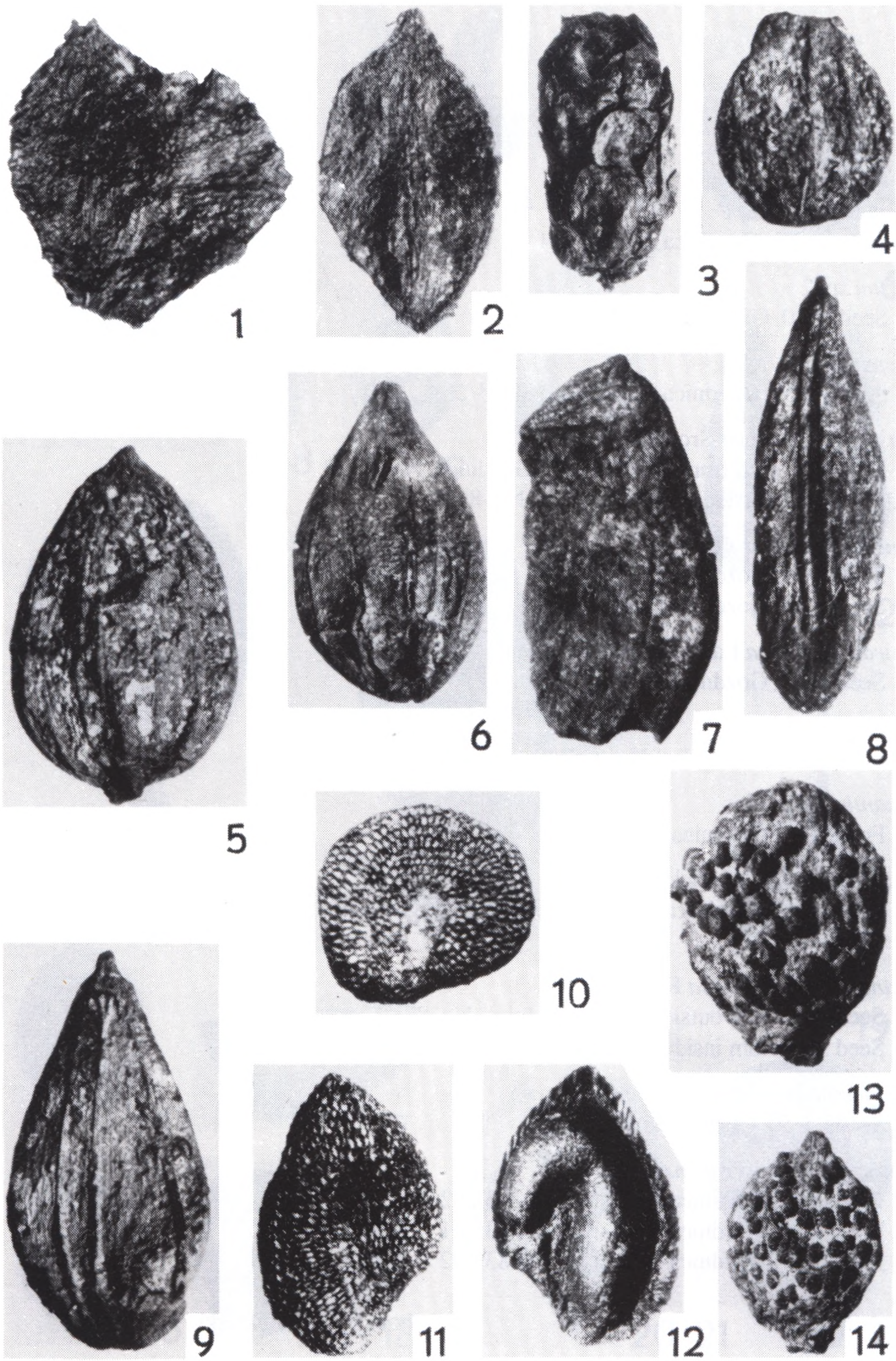
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Plate 16

Hypericum sp. 1
1, 2. Seeds, x 30, Gozdnica, No. 83/3–1

Hypericum sp. 2
3. Seed, x 30, Gozdnica, No. 83/295

Hypericum sp. 3
4, 5. Seeds, x 30, Gozdnica-Stanisław, No. 83/268

Clethra friisii Łańcucka-Środoniowa, *sp. nov.*
6. Holotype, seed from outside, x 30, Gozdnica, No. 83/43
7. Seed from outside, x 40, Gozdnica, No. 83/43

Andromeda nigra Dorofeev
8. Seed, x 15, Gozdnica, No. 83/26–1
9. Seed, x 25, Gozdnica, No. 83/26–1

Andromeda carpatica Łańcucka-Środoniowa
10. Seed, x 15, Gozdnica, No. 83/27

cf *Lyonia* sp.
11, 12. Seeds, x 20, Gozdnica, No. 83/74

cf. *Enkianthus* sp.
13. Fruit, x 11, Gozdnica, No. 83/47

Enkianthus camplanatus Nakai
14. Fruit, x 14, Botanical Garden, Faculty of Agricultur, Hokkaido University, Sapporo, Japan, KRAM-P

Aldrovanda praevesiculosa Kirchheimer
15. Seed seen from outside, x 20, Gozdnica, No. 83/25–1
16. Seed seen from inside, x 20, Gozdnica, No. 83/25–1

Vaccinium minutulum Łańcucka-Środoniowa
17 18. Seeds, x 50, Gozdnica, No. 83/299

cf. *Pirocarpella aquisgranensis* Mai
19. Fruit, x 17, Gozdnica-Stanisław, No. 83/262–1
20. Fruit, x 15, Gozdnica-Stanisław, No. 83/261
21. Fruit, x 17, Gozdnica-Stanisław, No. 83/262

photo by A. Pachoński

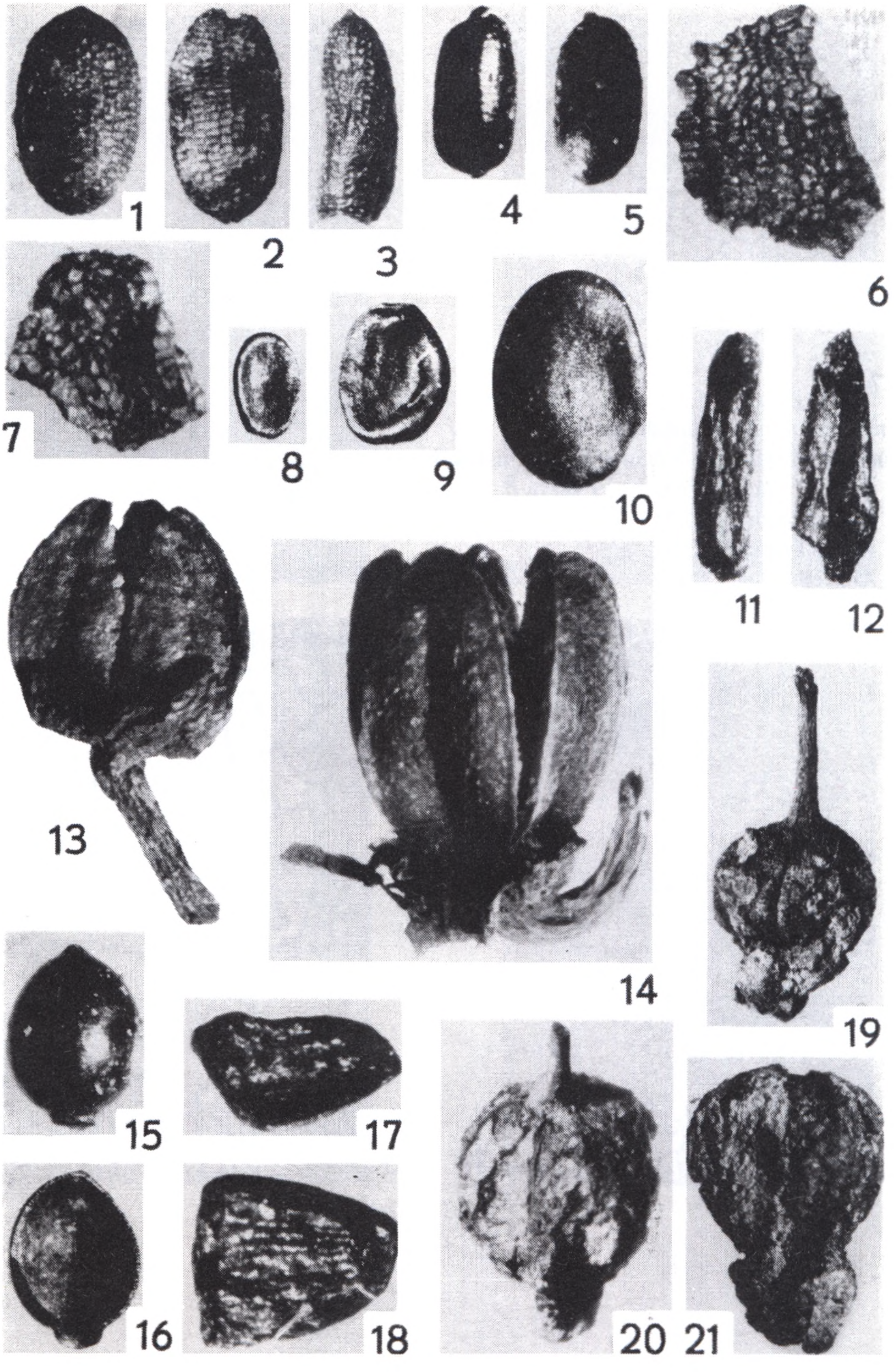
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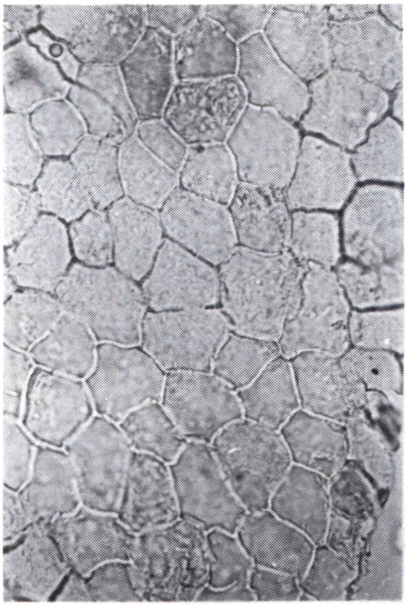
Plate 17

'*Viburnum*' *atlanticum* Ettingshausen

Cuticulae dispierse from Gozdnica-Stanisław, No. 83/163

1. Adaxial cuticle, x 500
2. Abaxial cuticle, x 200
3. Abaxial cuticle, x 500
4. Abaxial cuticle, x 500

photo by Z. Kvaček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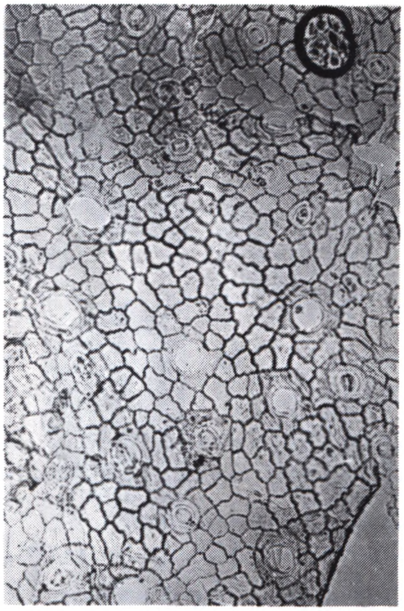
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Plate 18

cf. *Pirocarpella aquisgranensis* Mai
1, 2. Fruits, x 15, Gozdnica-Stanisław, No. 83/261

Melastomites tertiaria Dorofeev
3–5. Seeds, x 20, Gozdnica, No. 83/68–1

Rubus microspermus C. & E. M. Reid
6, 7. Fruits, x 20, Gozdnica-Stanisław, No. 83/279, 280

Rubus sp.
8. Fruit, x 20, Gozdnica-Stanisław, No. 83/281

Ludwigia palustris (L.) Ell. fossilis
9, 10. Seeds (9 – x 30, 10 – x 40), Gozdnica, No. 83/2–1

Ludwigia cf. *corneri* Friis
11, 12. Seeds, x 30, Gozdnica, No. 83/296

Proserpinaca brevicarpa Dorofeev
13, 14. Fruits, x 15. Gozdnica-Stanisław, No. 83/276

Gleditsia knorrii (Heer) Gregor
15, 16. Fragments of pods, x 4, Gozdnica, No. 83/294, No. MGUWr 6551p-2

Ilex saxonica Mai
17, 18. Endocarp seen from both sides, x 10, Gozdnica, No. 83/24–1

photo by A. Pachoński

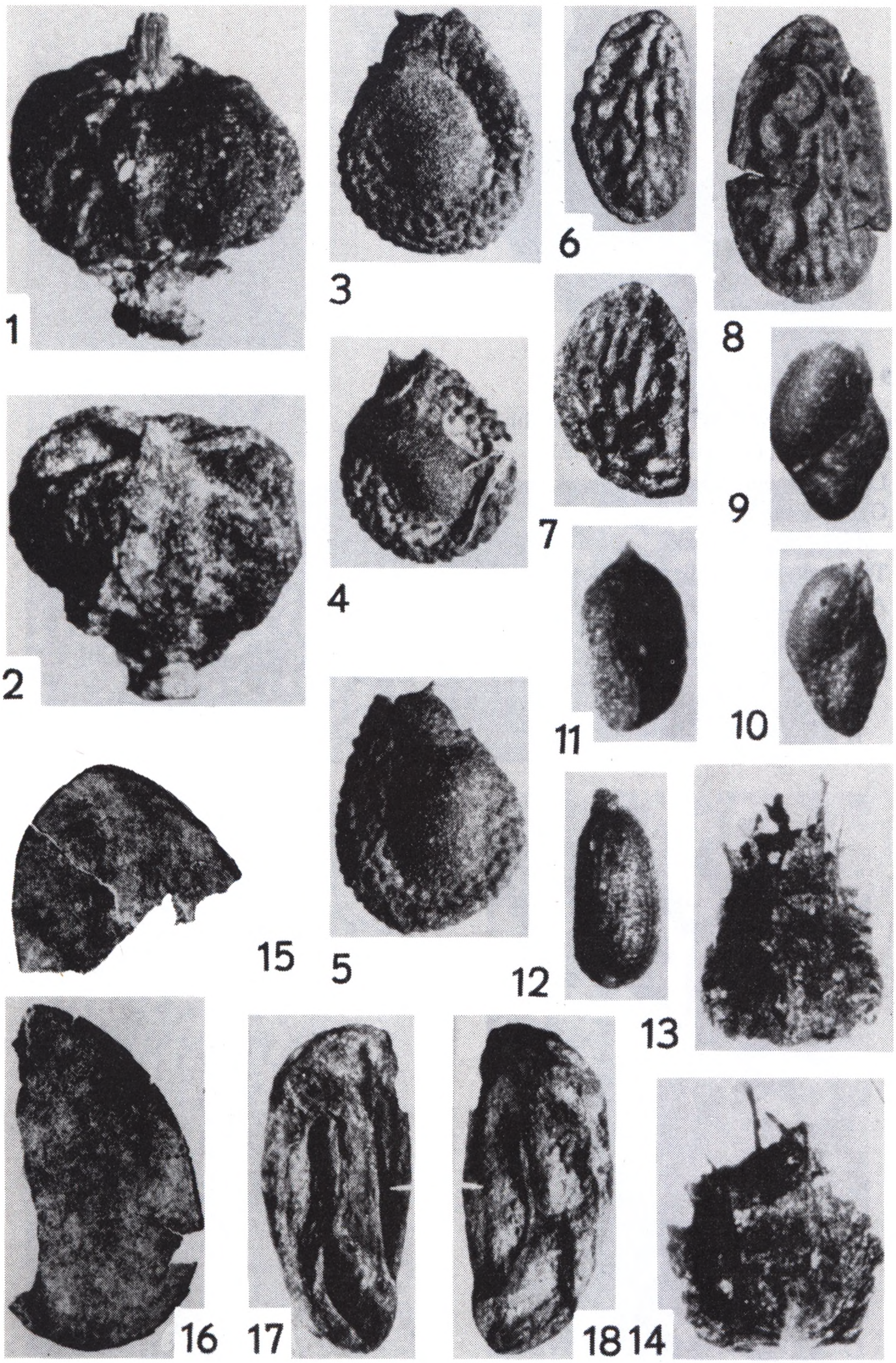
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Plate 19

Vaccinioides lusatica (Litke) Kvaček & Walther

Specimen from Gozdnica No. 83/321

1. Leaf fragment, x 5
2. Gland of the leaf margin, x 200
3. Adaxial cuticle, x 200
4. Trichome base in abaxial cuticle, x 500

5, 6. Abaxial cuticle with stomata (5 – x 200, 6 – x 500)

photo by Z. Kvaček

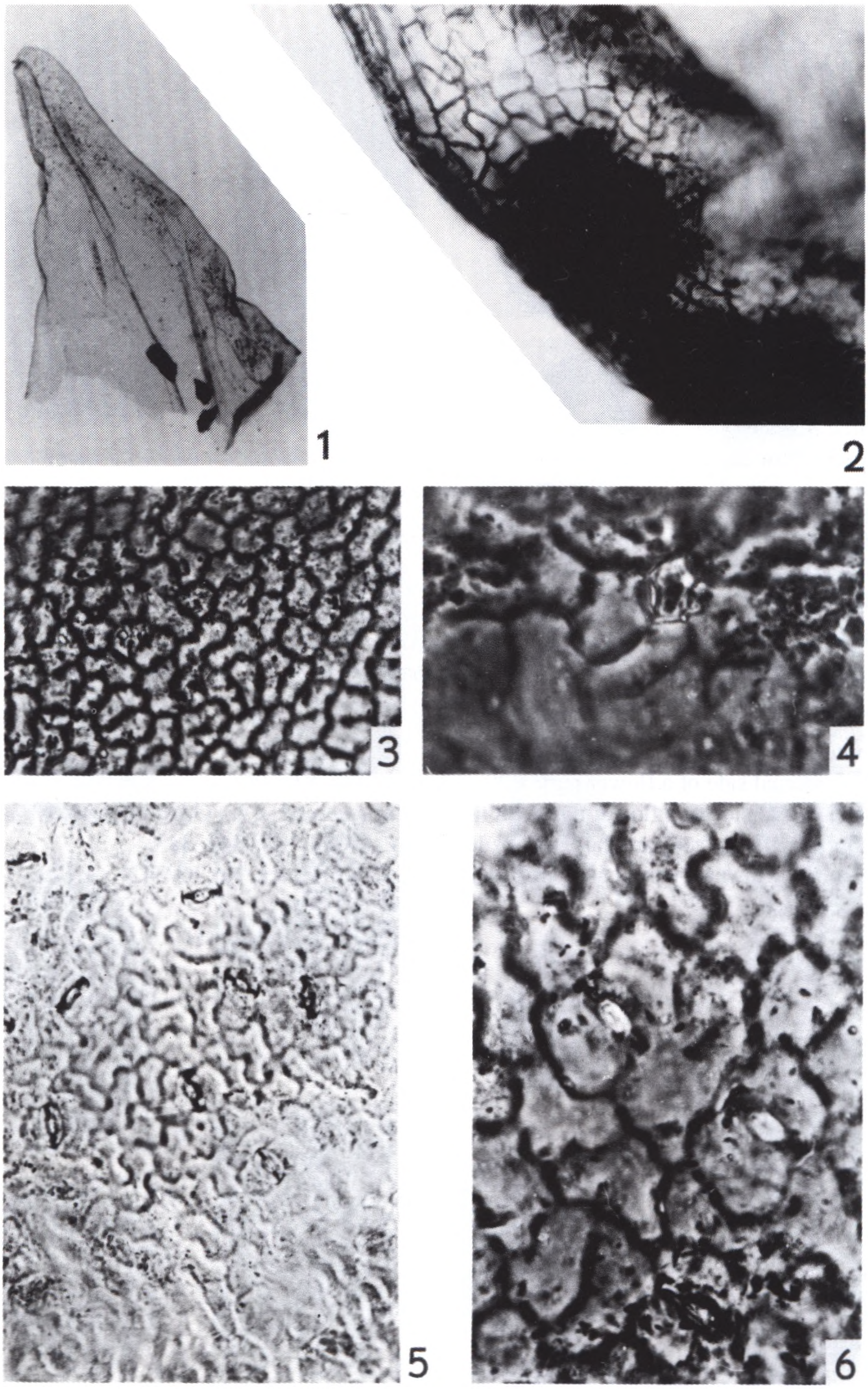
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Plate 20

Ilex saxonica Mai

1. Endocarp, x 10, Gozdnica, No. MGUWr 6561p

2, 3. Endocarp seen from both sides, x 10, Gozdnica, No. 83/24–1

Arceuthobium oxycedroides Łańcucka-Środoniowa, *sp. nov.*

4. Holotype, fruit, x 20, Gozdnica, No. 83/352

5, 6. Fruits, x 20. Gozdnica, No. 83/352

Arceuthobium tertiaerum Łańcucka-Środoniowa, *sp. nov.*

7, 9. Fruits, x 20, Gozdnica, No. 83/353, No. 83/354

8. Holotype, fruit, x 20, Gozdnica, No. 83/354

Arceuthobium sp.

10. The external side of a flower part, x 20, Gozdnica, No. 83/349

11. The internal side of a flower part with the anther preserved, x 20, Gozdnica, No. 83/349

12–15. Staminate flowers 4-parted, x 20, Gozdnica, No. 83/344, 347, 345, 343

16. Staminate flower 4-parted at the top of shoot, x 20, Gozdnica, No. 83/342

photo by A. Pachoński

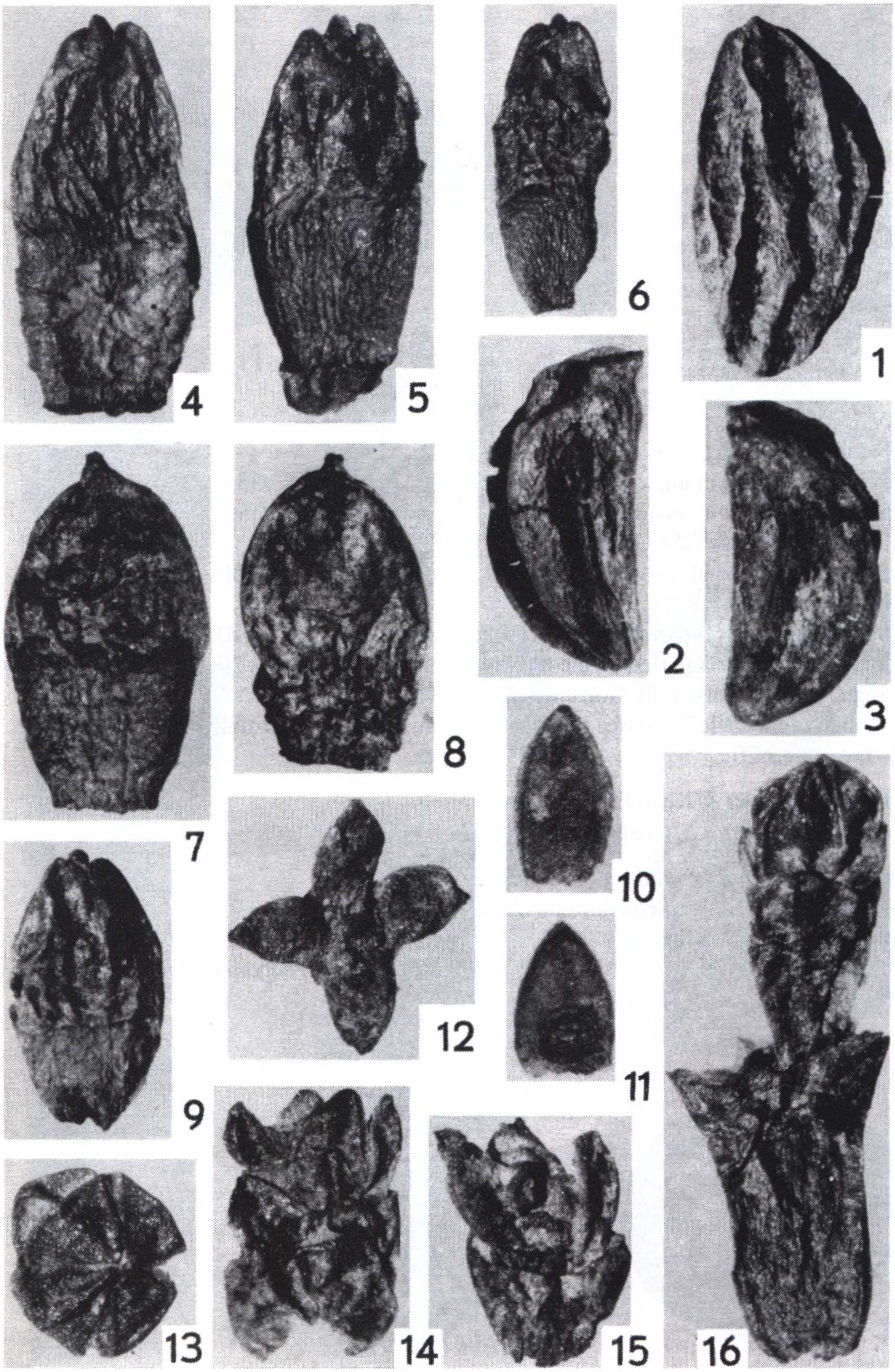
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Plate 21

Arceuthobium sp.

1–5. Female specimens.
1. Pistillate flowers at the top of a shoot, x 20, Gozdnica, No. 83/351
2. Shoot segment with pistillate flowers, x 20, Gozdnica, No. 83/351

3, 4. Pistillate flowers, x 20, Gozdnica, No. 83/350

5. Shoot fragment with pistillate flowers, x 20, Gozdnica, No. 83/350

6–7. Male specimens.
6. Staminate flower 3-parted on the terminal segment of a shoot, x 20, Gozdnica, No. 83/346
7. Staminate flower 3-parted on the terminal segment of a shoot, x 20, Gozdnica, No. 83/348

8, 9. Segments of shoots, x 20, Gozdnica, No. 83/340, 341

10. Branch of the undefinied tree infected dwarf mistletoe, x 6 Gozdnica, *s.n.*

10a – the same x 20

Viscum miquelii (Geyler & Kinkelin) Czeczott

11. Clearified leaf, x 1.5, Gozdnica, No. 83/92

Paliurus cf. *ramosissimus* Poiret

12, 13. Fruits, x 7. Gozdnica-Stanisław, no 83/274

photo by A. Pachoński

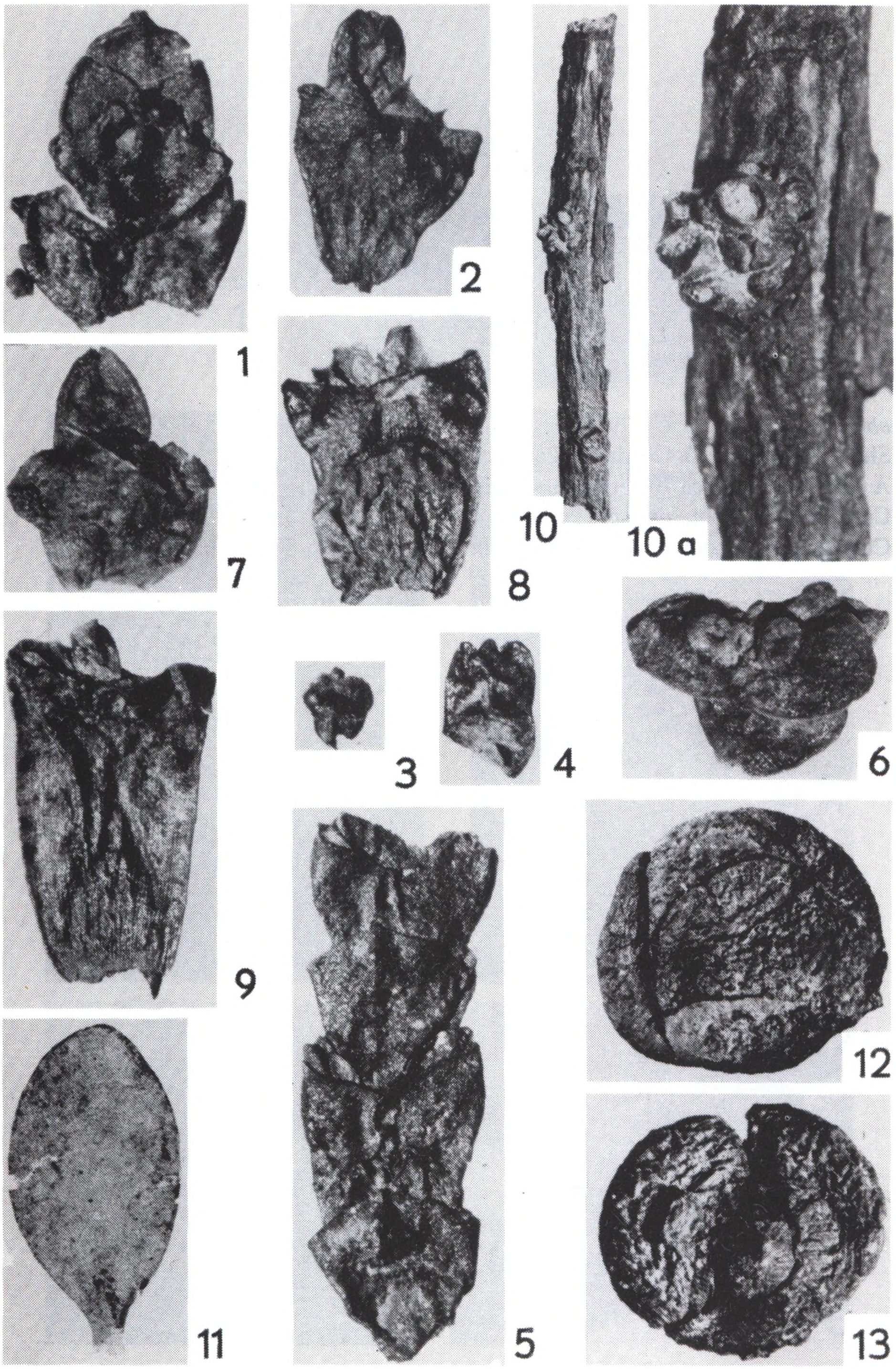
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Plate 22

Arceuthobium sp.

1. Shoot segment, x 10, Gozdnica-Stanisław, No. 83/323
2. A pair of bracts, x ca 70, Gozdnica-Stanisław, No. 83/234

3, 4. Cuticle of the shoot, same preparation, x 200

5, 6. Cuticle of the bract with stomata, same preparation (5 – x 500, 6 – x 200)

photo by Z. Kvaček

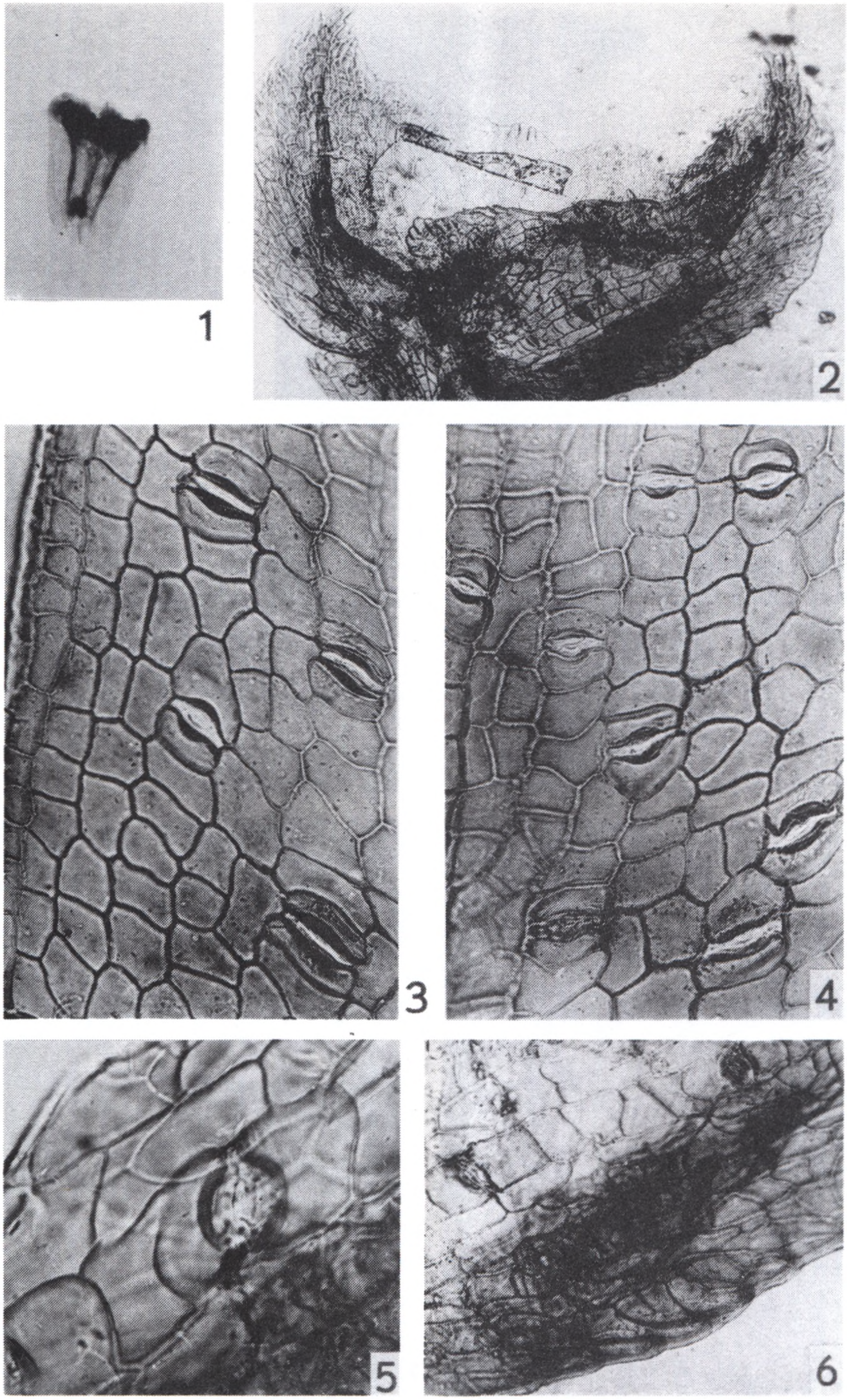
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Plate 23

Viscum miquelii (Geyler & Kinkelin) Czeczott

1. Twig fragment, x 5, Gozdnica, No. 83/314
2. Papillae on cuticle of the bract shown in Fig.3, x 500
3. Shortened segment with a pair of bracts, x 10, Gozdnica, No. 83/319
4. Pseudoberry with stylar rest and tepal scars, x 10, Gozdnica, No. 83/318
5. Epicarp cuticle with a stoma and hydatods of the specimen shown in Fig. 4, x 500
6. Dispersed leaf cuticle, x 500, Gozdnica, No. 83/320

photo by Z. Kvaček

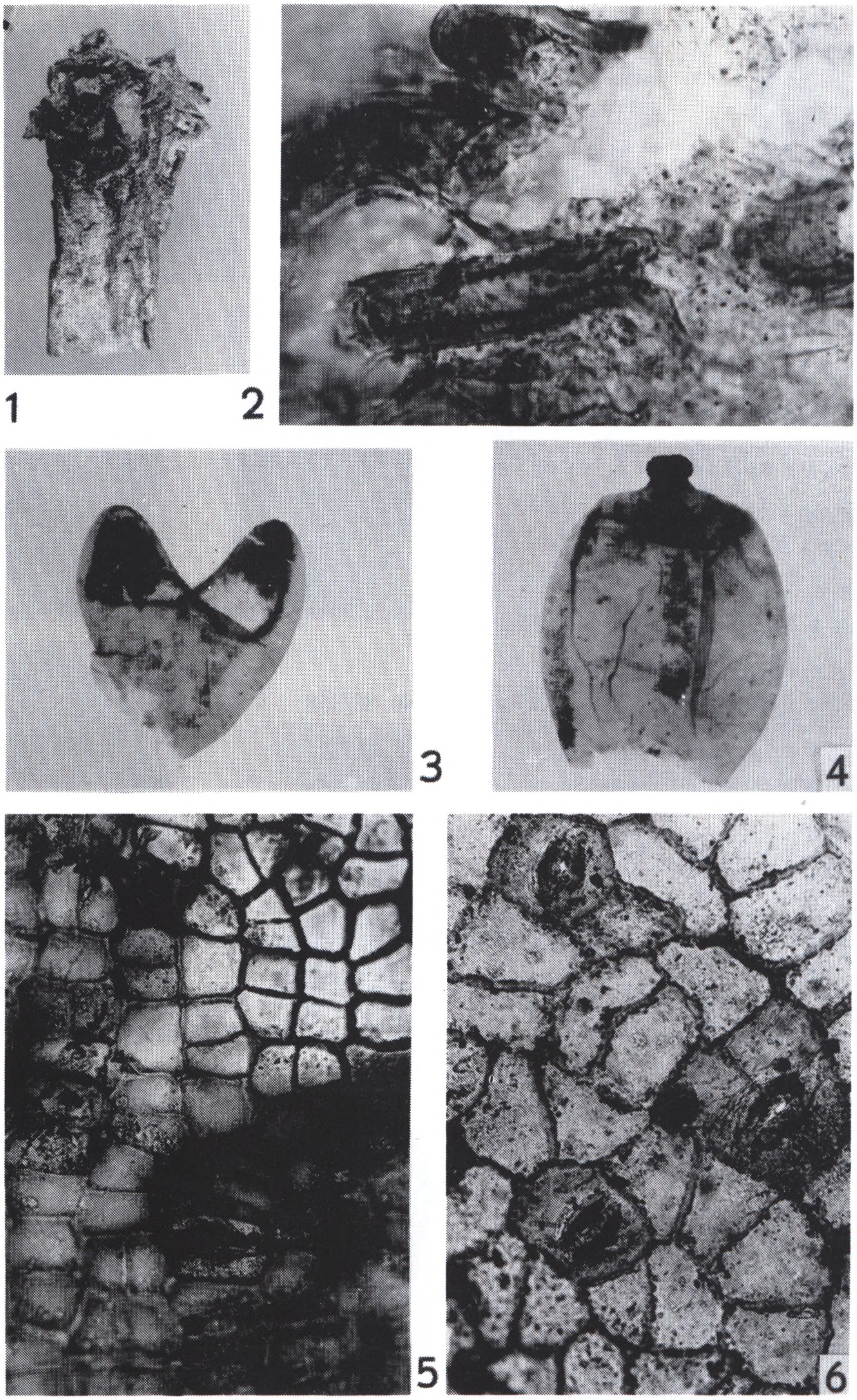
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Plate 24

Swida sp.
1. Endocarp, x 10, Gozdnica, No. 6558p MGUWr

Alisma ex gr. *plantago* L. fossilis
2, 3. Seeds, x 20, Gozdnica, No. 83/29–1

cf. Labiatae gen.
4. Fruit, x 20, Gozdnica-Stanisław, No. 83/270

Tectocarya lusatica Kirchheimer
5, 6. Fruit seen from both sides, x 1.2, Gozdnica, No. 83/358

Pentapanax tertiarius Mai
7, 8. Endocarps, x 10, Gozdnica, No. 83/7–1

cf. *Sagittaria* sp.
9, 10. Seeds, x 20, Gozdnica, No. 83/28–1

Smilax sp.
11, 12. Abaxial cuticle (11 – x 200, 12 – x 500), Gozdnica-Stanisław, No. 83/164

1–10 photo by A. Pachoński
11, 12 photo by Z. Kvaček

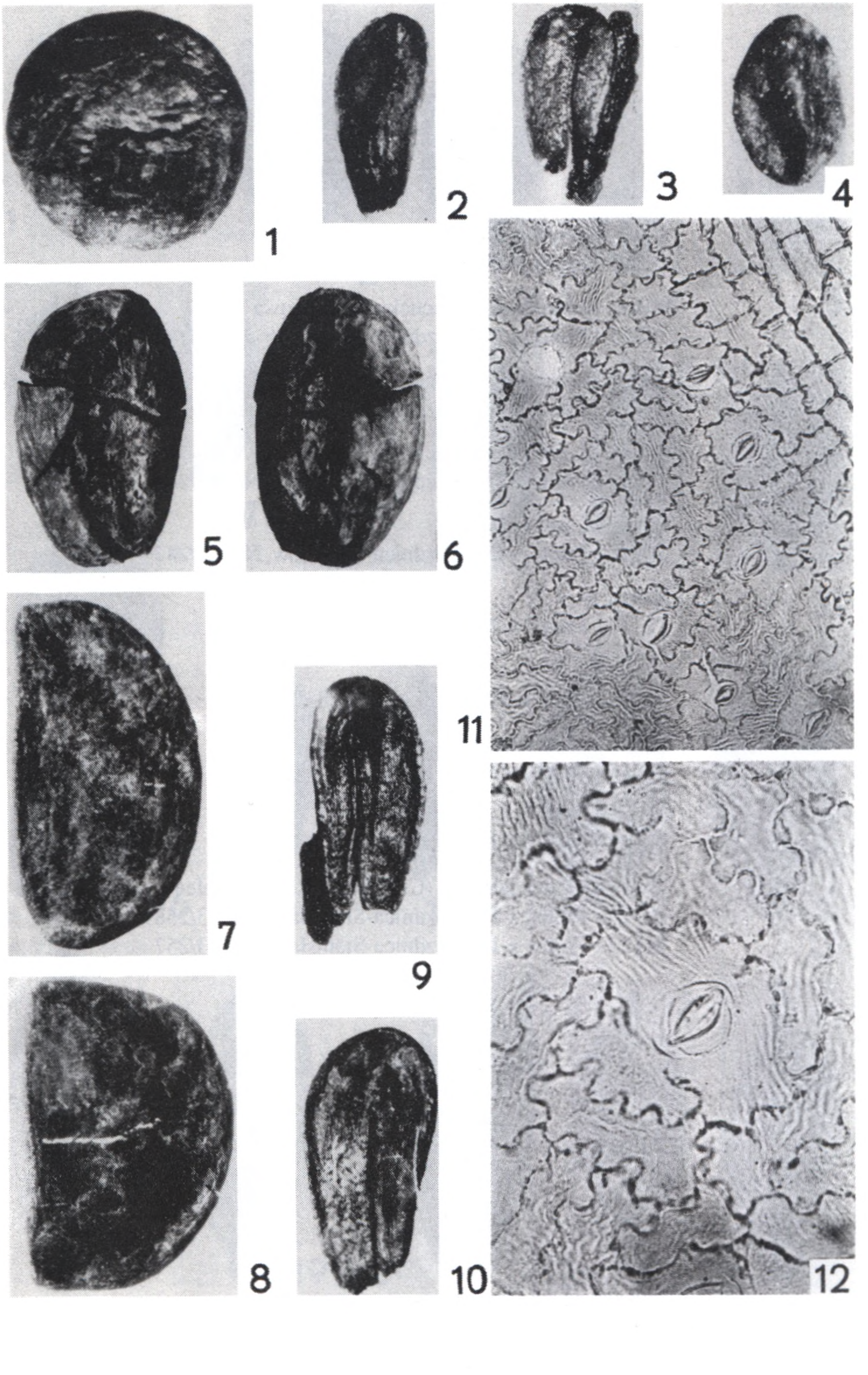

Plate 25

Carex caespitosa L. fossilis
1, 2. Fruits, x 20, Gozdnica, No. 83/37–1

Carex elongatoides Łańcucka-Środoniowa
3–5. Fruits, x 20, Gozdnica, No. 83/36

Carex flavaeformis Łańcucka-Środoniowa
6, 7. Fruits, x 20, Gozdnica-Stanisław, No. 83/244

Carex cf. *plicata* Łańcucka-Środoniowa
8, 9. Fruits, x 30, Gozdnica-Stanisław, No. 83/245

Carex cf. *ungeri* Mai
10, 11. Fruits, x 20, Gozdnica-Stanisław, No. 83/247

Carex sp. 1
12, 13. Fruits, x 20, Gozdnica, No. 833/291

Carex sp. 2
14. Fruit, x 20, Gozdnica, No. 83/292

Caricoidea globosa (C. & E. M. Reid) Mai
15, 16. Fruits, x 20, Gozdnica, No. 83/30–1

Cyperus sp.
17, 18. Fruits, x 30, Gozdnica, No. 83/70–1

Dulichium marginatum (C. & E. M. Reid) Dorofeev
19, 20. Fruits, x 15, Gozdnica-Stanisław, No. 83/258
21, 22. Fruits, x 15, Gozdnica-Stanisław, No. 83/257

photo by A. Pachoński

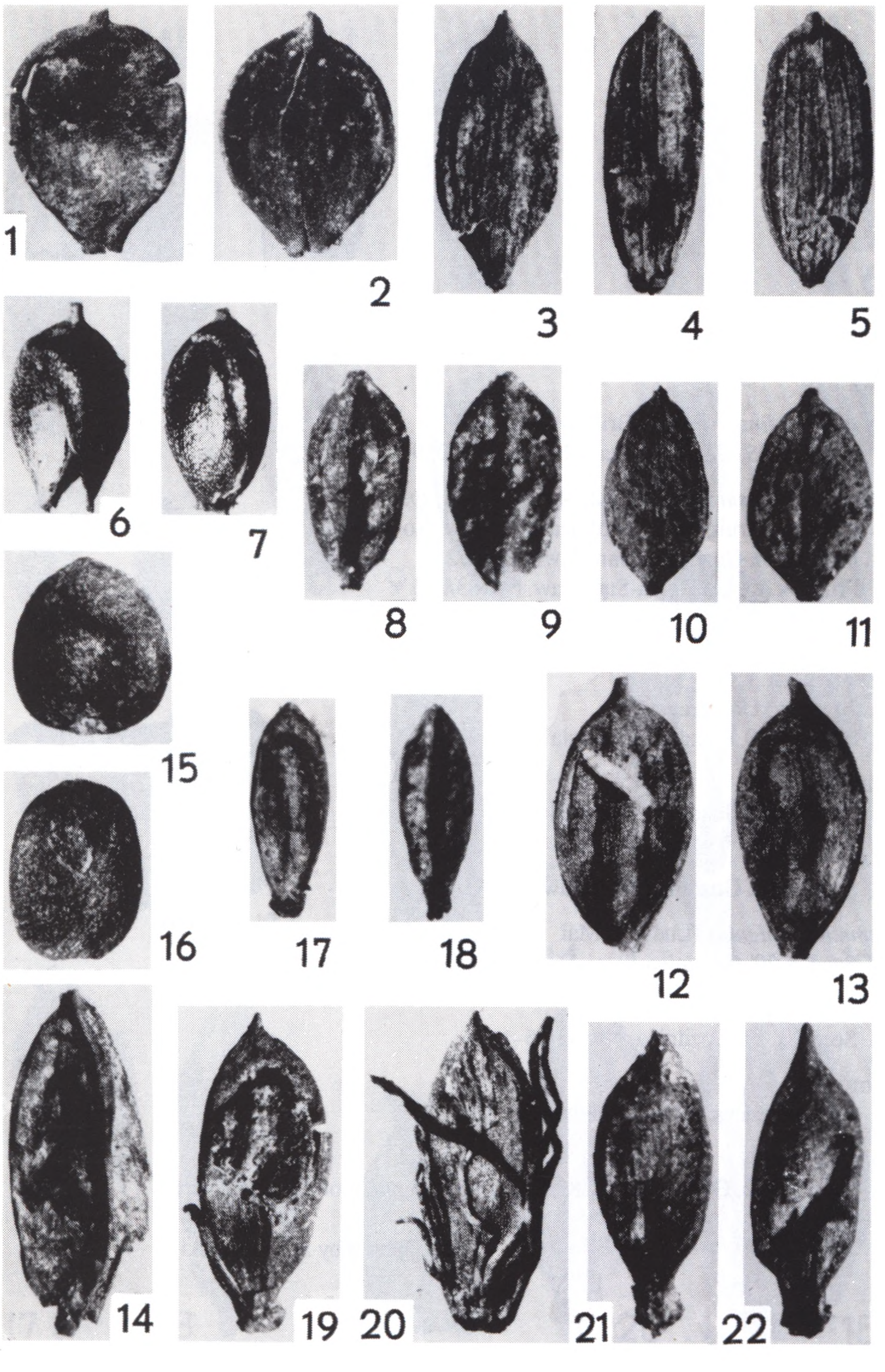
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Plate 26

Dulichium arundinaceum (L.) Britton fossilis
1, 2. Fruits, x 15, Gozdnica-Stanisław, No. 83/259

Trichophorum silesiacum Łańcucka-Środoniowa, *sp. nov.*
3. Holotype, fruit, x 30, Gozdnica-Stanisłąw, No 83/256
4. Fruit, x 30, Gozdnica-Stanisław, No. 83/256
5, 6. Fruits, x 30, Gozdnica-Stanisław, No. 83/255

Scirpus sylvaticus L. fossilis
7, 8. Fruits, x 30, Gozdnica-Stanisław, No. 83/284

Scirpus ragozinii Dorofeev
9, 10. Fruits, x 20, Gozdnica-Stanisław, No. 83/285

cf. Gramineae gen.
11. Fruit, x 20, Gozdnica, No. 83/46–1

Typha sp.
12. Seed, x 30, Gozdnica-Stanisław, No. 83/288

Epipremnites reniculus (Ludwig) Mai
13. Seed, x 20, Gozdnica-Stanisław, No. 83/260

Carpolithes natans Nikitin *ex* Dorofeev
14, 15. Seeds, x 10, Gozdnica, No. 83/35–1

Indeterminatae
16. Inflorescences, x 10, Gozdnica, No. 83/77

Carpolithes sp.
17–20. Fruits, x 20, Gozdnica, No. 83/52–1; 19 – fragment of the upper part

photo by A. Pachoński

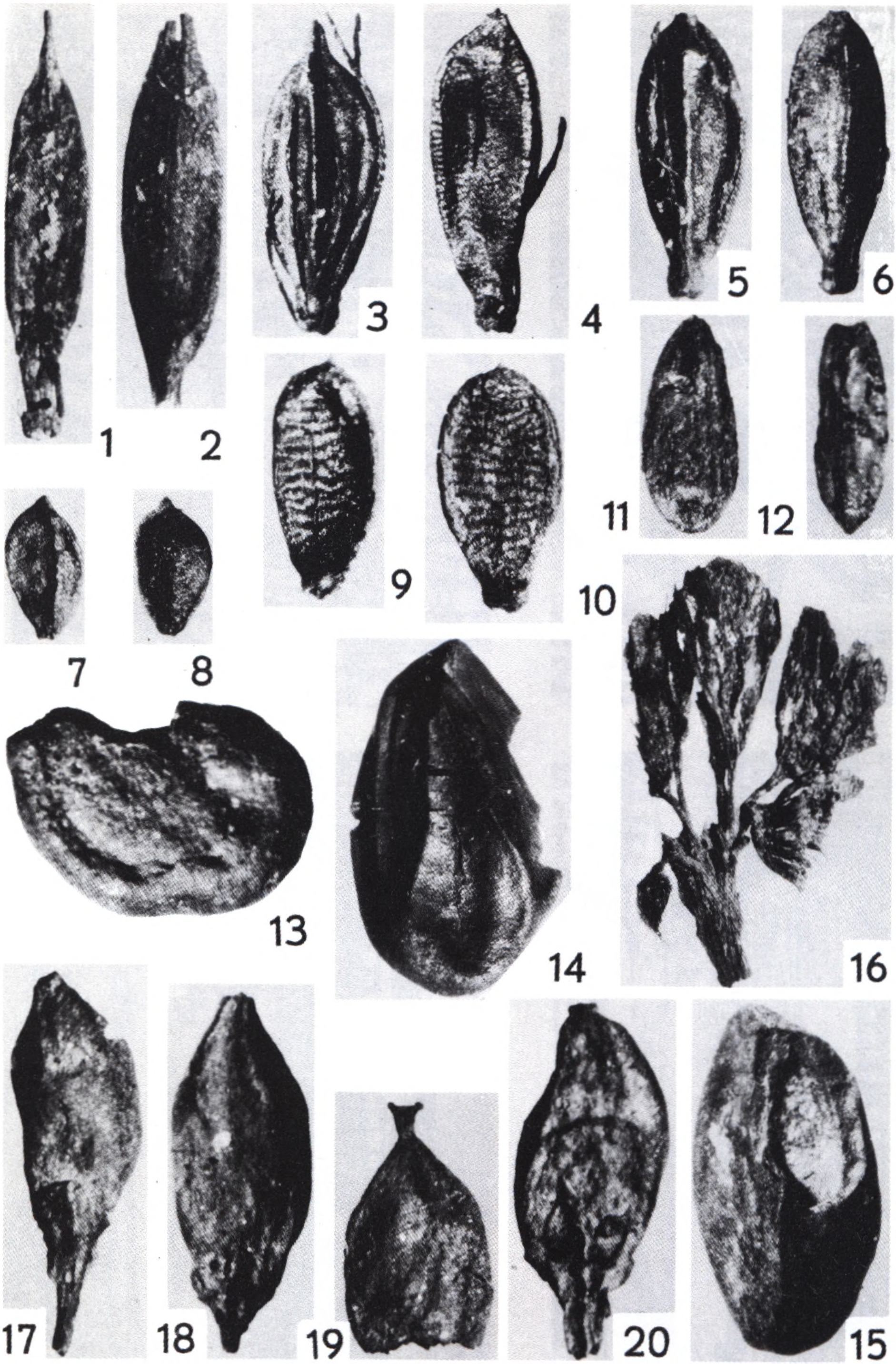
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Plate 27

Taxodioxylon taxodii Gothan

1, 2. Transverse section (1 – x 166, 2 – x 650)

3, 4. Tangential section, x 166

photo by W. Pyszyński

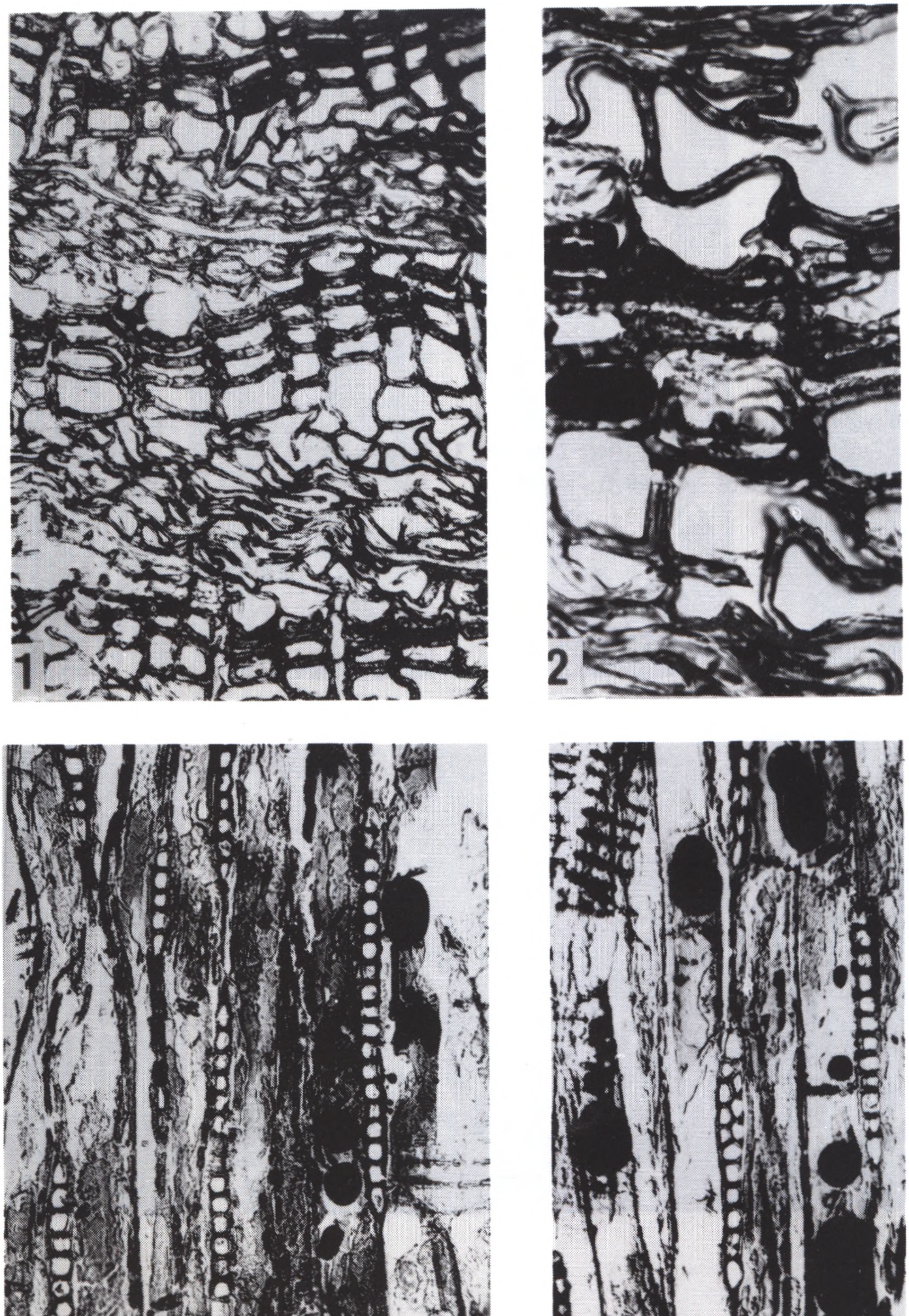
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Plate 28

Taxodioxylon taxodii Gothan
1–3. Tangential section (1 – x 1040, 2 – x 650, 3 – x 1400)
4, 5. Radial section (4 – x 1040, 5 – x 800)

photo by W. Pyszyński

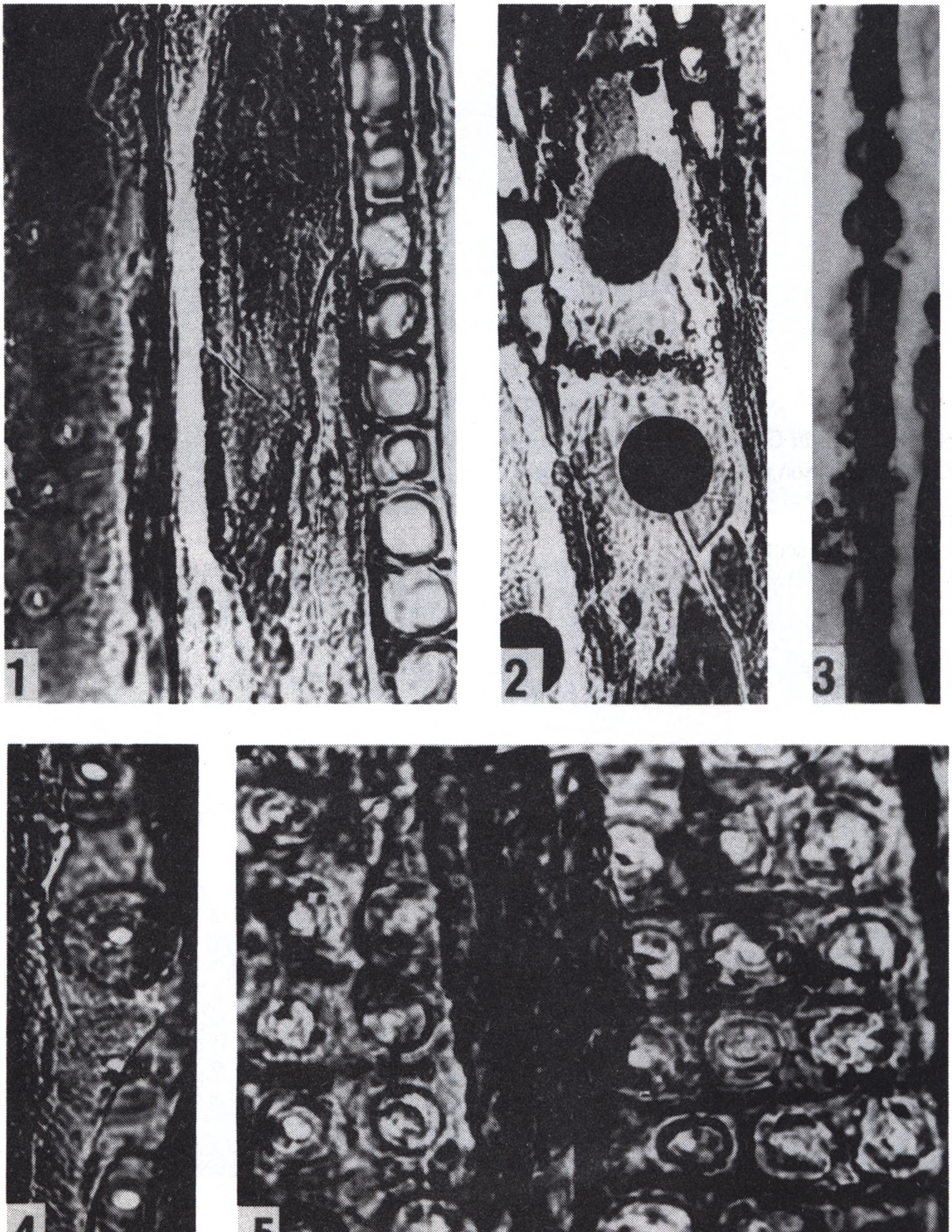
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Plate 29

Taxodioxylon taxodii Gothan
1, 2. Radial section (1 – x 650, 2 – x 1040)

Quercoxylon sp.
3. Transverse section, x 67

photo by W. Pyszyński

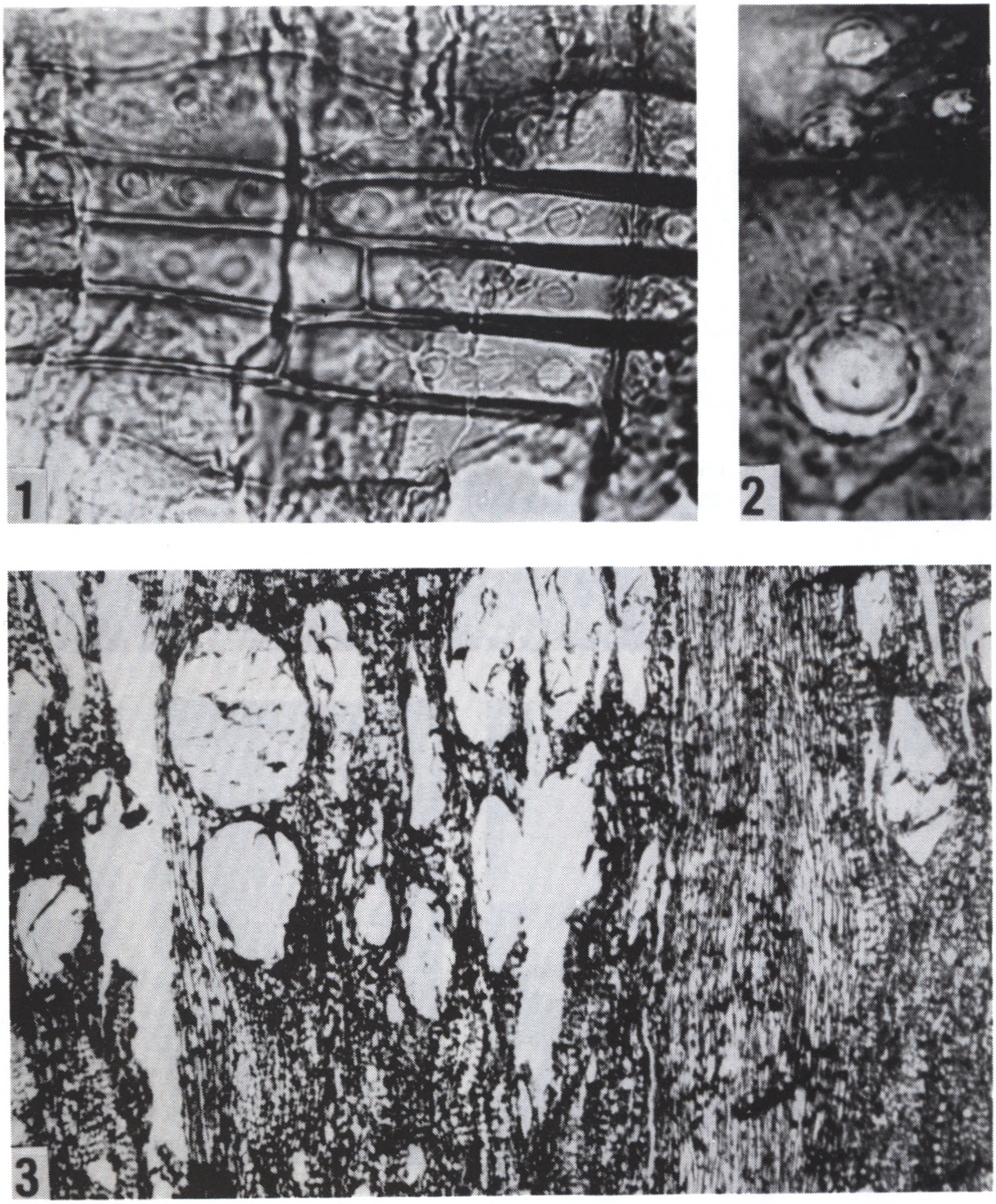
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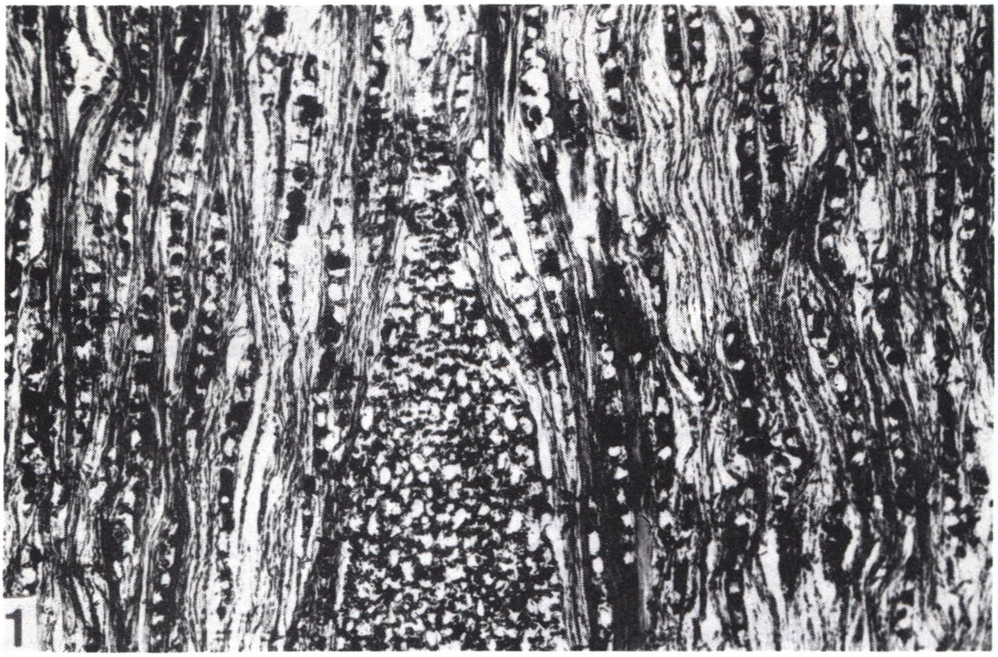
Plate 30

Quercoxylon sp.

1. Tangential section, x 166

2–4. Radial section (2 – x 800, 3 – x 800, 4 – x 650)

photo by W. Pyszyński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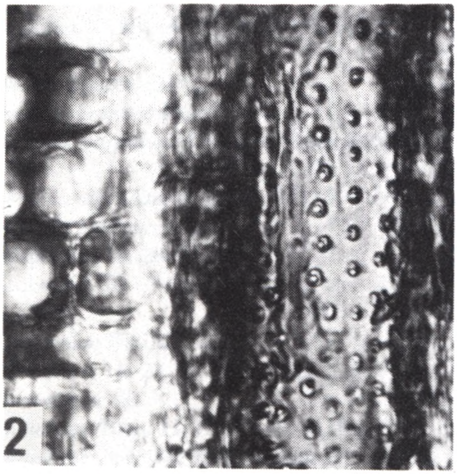
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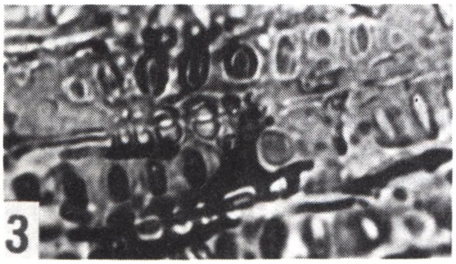
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Index

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