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TORTONIAN FLORA FROM THE „GDÓW BAY" IN THE SOUTH OF POLAND

Flora tortońska „Zatoki Gdowskiej"

CONTENTS

INTRODUCTION

In the period 1947—1952, on the initiative of the Central Board of the Petroleum Industry in Cracow, several deep exploratory drillings were carried out on the foreland of the Carpathians among the localities of Wieliczka—Bochnia—Gdów. In geological literature this region is known under the name of „Gdów Bay". From these drillings I received for palaeobotanical investigation 80 samples which contained plant material in the

form of small detritus and numerous lignites. In spite of the paucity of the material and poor preservation of flora I have attempted to investigate it in view of the importance of thick deposits of the „Gdów Bay" to the knowledge of the geology and origin of the Tortonian Sea deposits.

Miocene deposits of this part of the foreland of the Carpathians have been investigated by several geologists and palaeontologists. Recent years have furnished new data, especially from the field of stratigraphy based on macro- and microfauna. The majority of profiles which were to be investigated palaeobotanically have been the subject of palaeontological studies, hence the stratigraphy of the Miocene of these areas now no longer raises any essential doubts.

Previous reports of fossil plants from the Miocene region under discussion were confined to the results of investigations of the flora occurring in the salt-beds of Wieliczka (Unger 1850; Stur 1873; Zabłocki 1928, 1930, 1960; Zabłocka 1931; Kirchheimer 1941a, 1950) and to those spore-pollen analyses of the Kłaj 1 drilling core (Kita 1963).

Throughout the long work on the flora of the „Gdów Bay" I have always had the benefit of help readily given by several persons which I take this opportunity to acknowledge warmly. My thanks are due to the following: Prof. W. Szafer for valuable advices and criticism, Dr. Z. Olewicz for supplying me with material from drillings, discussion, and permission to consult the manuscript of his work, Prof. B. Szafran for the identification of mosses, Dr. J. Oszast for carrying out spore-pollen analysis on a number of deposit samples, Dr. M. Białobrzeska and Dr. J. Truchanowicz for the biometric analysis of nuts of the genus *Betula*, Dr. M. Reymanówna and Mrs. B. Pawlikowa for help in preparing difficult anatomical slides and to Mr. S. Łuczko for taking the photographs included in the present paper. I owe special thanks to my husband, Prof. A. Środoń, who has watched over the realization of the whole of my investigations.

I. GENERAL PART

GEOLOGY

STRATIGRAPHICAL POSITION OF DEPOSITS

The part of the Carpathian foreland lying between Wieliczka in the west, Bochnia in the east, and Gdów in the south is covered with Miocene marine deposits resting directly on the Jurassic or Cretaceous substratum. These deposits, sometimes reaching a thickness of over 1000 m, fill up the Subcarpathian foredeep genetically connected with the emergence of the Carpathians and many times deepened later on.

According to the classification nowadays adopted by geologists and palaeontologists, the Tortonian is made up of two substrata: the Lower Tortonian (Opolian) and the Upper Tortonian (Grabovian), while the level of chemical deposits in the top of the Lower Tortonian is regarded as a distinct leading horizon. In recent years there have appeared some more detailed divisions of the Tortonian substrata into stratigraphical levels based on macrofauna (K r a c h 1958, 1962) or microfaunistic assemblages (K i r c h n e r 1956, 1962; A l e x a n d r o w i c z 1958, 1961; Ł u c z k o w s k a 1955, 1958, 1963). However, in view of the existing differences in individual stratigraphical arrangements of the Tortonian substages, I am submitting a simplified scheme which is, in my opinion, quite sufficient for palaeobotanical purposes (Table 1).

The stratigraphy of the deposits which yielded the palaeobotanically investigated samples does not raise any essential doubts. Some of the drilling profiles contain saliferous series (the level of chemical deposits) but mainly they represent various subchemical deposits such as subsaline marls, sandy series, and bottom marly shales. On this basis it is possible to link these profiles with the Lower Tortonian.

This estimate is confirmed by investigations of macrofauna (identifications of Prof. W. K r a c h in the work of Z. O l e w i c z, 1964) and microfauna (Ł u c z k o w s k a 1955, 1958). In a few profiles microfauna was not investigated but their stratigraphical position is not questioned as it was possible to correlate it on the lithological basis.

The Kłaj 1 profile has a different stratigraphical position. In this profile, above the saliferous series, there lie silty and sandy deposits of considerable thickness belonging to the Upper Tortonian age, which has been established on the basis of microfaunistic investigations (K i r c h n e r 1956, 1962).

The geology of the area under discussion has been in recent years the subject of detailed studies by Z. O l e w i c z (1962, 1964).

Table 1
Tabela 1

A stratigraphical scheme of Tortonian and Lower Sarmatian deposits of Southern Poland with reference to the position of some fossil floras.
Schemat stratygraficzny osadów tortonu i dolnego sarmatu południowej Polski z uwzględnieniem pozycji niektórych flor kopalnych

Geological age / Wiek geologiczny				Localities / Miejscowości: „Gilów Bay"	Wieliczka	Swoszowice	Stare Gliwice
SARMATIAN	Lower	Wolynian					
		Buhlovian					■
TORTONIAN	Upper	Grabovian		■			
	Lower	Opolian	chemical deposits	■	■	■	
			subchemical deposits	■			

DESCRIPTION OF GEOLOGICAL PROFILES

The samples which were subjected to palaeobotanical investigation came mainly from deep exploratory drillings which usually reached a depth of several hundred and, in some cases, more than 1000 metres (Książnice, Siedlec 3, Łapczyca 2, Kolanów). Apart from this, 6 samples were taken from surface exposures. The whole material comes from 24 stations situated in 19 localities (cf. Fig. 1).

From the lithological point of view, the profiles under discussion display a fairly considerable differentiation but in the course of individual series substantial similarities can be noticed. The synthetic profile made

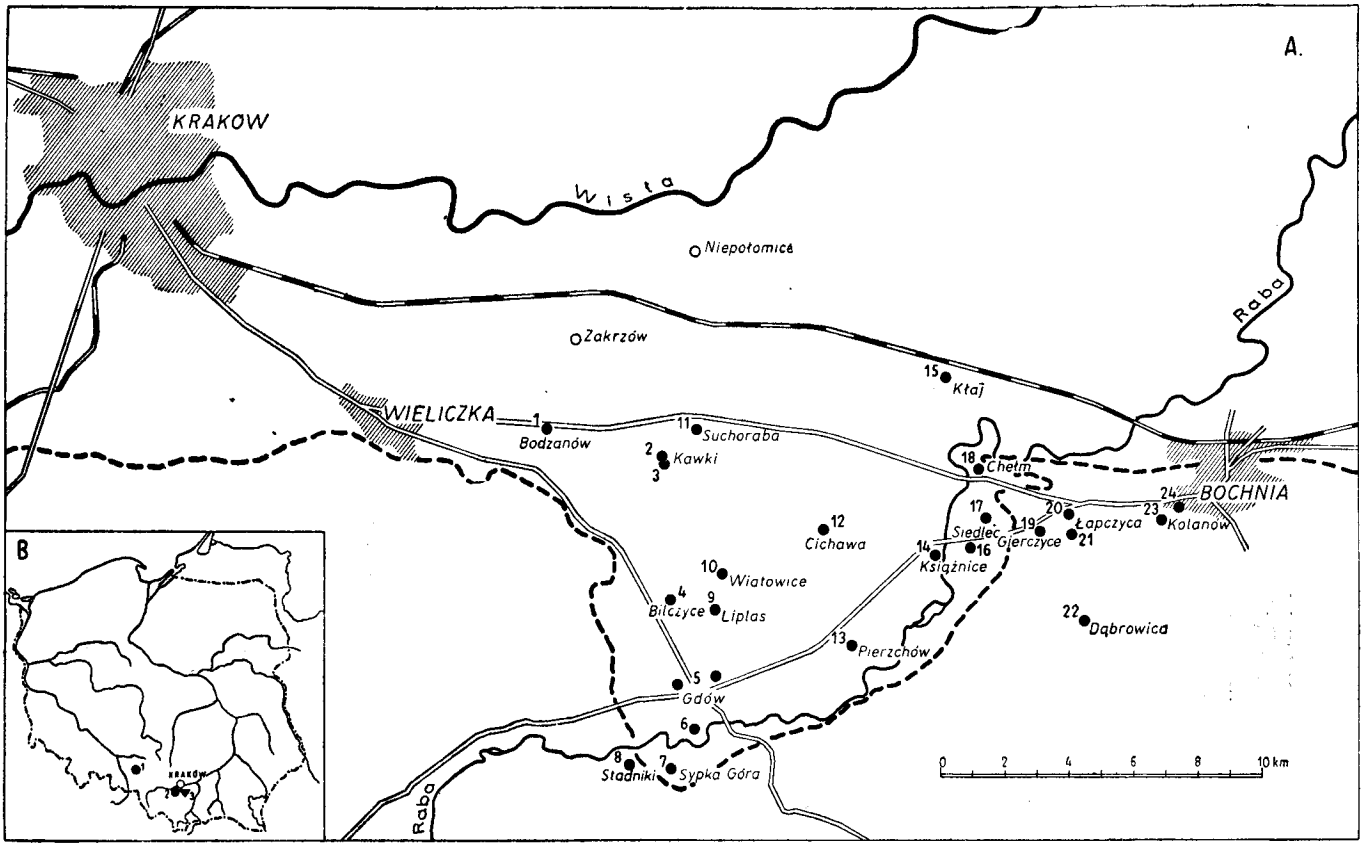


Fig. 1. A. Localities of Tortonian floras on the territory of the „Gdów Bay". Broken line denotes the range of encroachments of the Carpathian Flysch. B. 1 — Stare Gliwice, 2 — Swoszowice, 3 — The „Gdów Bay".

Ryc. 1. A. Stanowiska flor tortońskich występujących na obszarze „Zatoki Gdowskiej". Linia przerywana oznacza zasięg nasunięć fliszu karpackiego. B. 1 — Stare Gliwice, 2 — Swoszowice, 3 — „Zatoka Gdowska"

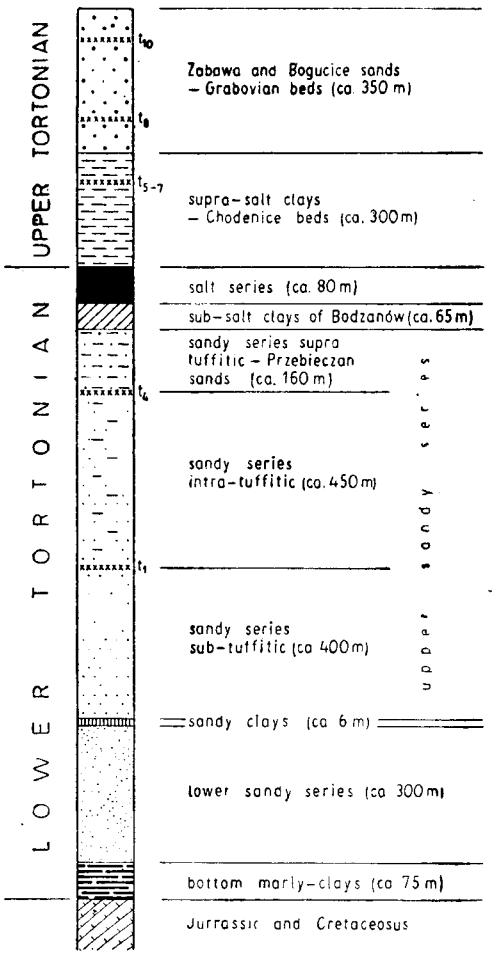


Fig. 2. A synthetic profile of Tortonian deposits of the „Gdów Bay" traced out on the basis of materials of Z. Olewicz (1962, 1964). Maximum depths are given for individual series. Crosses denote tufaceous levels (t_1—t_{10}).

Ryc. 2. Profil syntetyczny osadów tortońskich „Zatoki Gdowskiej", wykreślony na podstawie materiałów Z. Olewicza (1962, 1964). Dla poszczególnych serii podane są przybliżone maksymalne miąższości. Krzyżykami oznaczone są poziomy tufitowe (t_1—t_{10})

available to me by Dr. Z. Olewicz has the following features (Fig. 2): on the Mesozoic substratum there rests a layer 30—70 metres thick of so called bottom marl silts. Above them there begins a series of silts and sands of considerable thickness (up to 1000 m.) whose lower part is marked by the dominance of sandy material while in the upper one the dominant role is played by silts. In the upper part of the series of sands and silts there occur two distinct tufaceous levels making it possible to distinguish in this series a supertufaceous part (about 150 m. in thickness), an intratufaceous one (over 300 m.), and a subtufaceous one (300—445 m.). The latter series is underlaid by a stratum of sandy silts (5—25 m.) and a lower sandy series (50—300 m.), passing at the bottom into so-called crustaceous sandstones. In the top of the series of sands and silts, already above its supertufaceous part, there occur silts and subsaline marls, known under the name of Bodzanów marls, and above them there lies a gypsosaliferous series (20—75 m.) with supersaline silts. Over the saliferous series there lie (Kłaj 1) deposits of silt and sand interspersed with tufaceous rocks and thicker sandy sediments.

For easier orientation as regards the origin of investigated samples I have assembled, on the basis of Dr. Z. Olewicz's data, in a single graph the schemes of drilling profiles (Fig. 3). In this graph individual lithological series are marked in a manner similar to that used in the synthetic profile (Fig. 2). Apart from drilling profiles, also surface

samples coming from different series are shown here. All the samples subjected to palaeobotanical analysis are marked with consecutive numbers.

The characteristic succession of layers can be followed in several profiles, although some of them constitute only small sections of the complete series of deposits. Profiles from the neighbourhood of Bochnia (Gierczyce, Łapczyca 1, 2, Dąbrowica, Kolanów and Bochnia) form a separate group. They are more complicated for they contain also elements of an overlying Flysch nappe. A special position is also held by the Kłaj 1 profile in which over the lower series there lie silty and sandy deposits of considerable thickness, this having already been stressed during the discussion of the stratigraphy of the region studied.

The greatest number of samples received for palaeobotanical analysis came from sandy deposits (51 samples). I had at my disposal 14 samples from supersaline silts, 6 samples from the saline series, 8 samples from subsaline silts, and 1 sample from bottom marly silts (Kolanów 78).

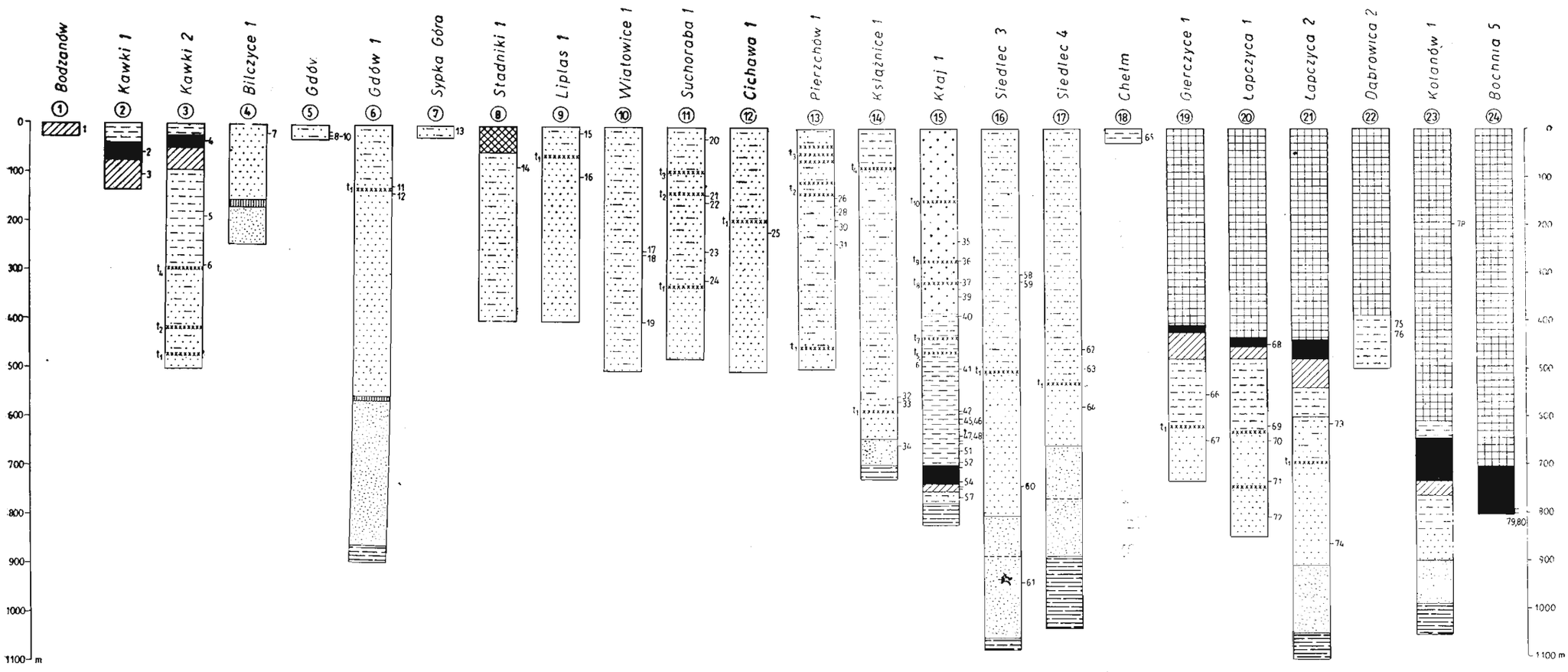
The number of samples from individual drillings varied. Sometimes, I had at my disposal only single samples; most frequently, however, there were several of them. The largest material (23 samples) came from the Kłaj 1 drilling.

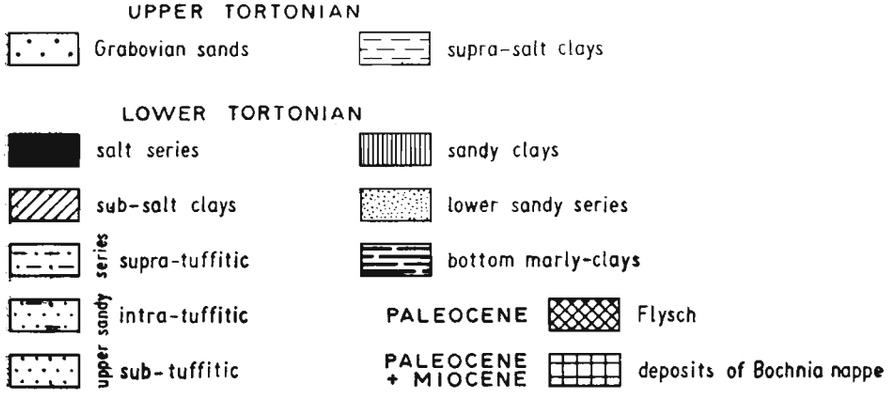
PALAEOBOTANY

DESCRIPTION OF THE MATERIAL

Samples for analysis were taken from profiles by Dr. Z. Olewicz only from horizons that were palaeobotanically more promising. It should be stressed that the number of horizons with visible plant detritus was considerably greater. The samples taken contained small plant detritus, visible to the naked eye, fragments of lignites and, sometimes, impressions of leaves. Larger lignites were found in 14 samples and small fragments of them occurred in all the analysed material. Lignites were not investigated since their strong carbonization and metamorphosis precluded even generic determination. Also impressions of leaves confirmed in 3 samples were too fragmentary to make identification possible.

Plant detritus occurred in sandy, silty, and marly samples. It was impossible to extract remains contained in hard saline sandstones (the sample from Bochnia). Unsuccessful also were attempts to isolate plant remains from Bodzanów marls because they dissolved during maceration in diluted HCl. Almost all the identified forms came from sandy or sandy-silty deposits so that their state of preservation could not be good. As a rule, they are strongly carbonaceous, mechanically abraded by the sandy surroundings, and crumble easily even when lightly dried out.





Ryc. 3. Profile geologiczne tortonu „Zatoki Gdowskiej" zbadane pod względem paleobotanicznym, zestawione na podstawie materiałów Z. Olewicza (1962, 1964). Liczby podane z boku profili oznaczają numery zbadanych prób. Krzyżyki wskazują poziomy tufitowe (t_1 — t_{10}). Liczby w kółkach, podane przy nazwach miejscowości odpowiadają stanowiskom na mapie (Ryc. 1)

Fig. 3. Geological profiles of the Tortonian of the "Gdów Bay" which were investigated paleobotanically, set out on the basis of materials of Z. Olewicz (1962, 1964). Numbers at the side of profiles denote numeration of samples examined. Crosses indicate tufaceous levels (t_1—t_{10}). Numbers in circles at the names of localities correspond to occurrence on the map (Fig. 1).

This bad state of preservation of the remains, their fragmentariness, and paucity, made analysis extremely difficult, and reduced the value of the results obtained. It was impossible, for instance, to remove the epidermis from the fairly numerous needles and therefore their diagnostic description is necessarily based on external morphology only. On this account identifications were in several cases confined to generic names. The results arrived at are assembled in Table 2. From this table it can be seen that out of the 80 samples received only 41, i.e. a half, contained plant remains which it was possible to identify more or less accurately.

PALYNOLOGICAL ANALYSIS

Apart from macroscopic plant analyses which were the main object of the present work tentative spore-pollen analyses were also carried out.

In 1958 Dr. J. Oszast analysed 5 samples from Suchoraba. Only one of them (sample 20), coming from a depth of 27 m., contained a fairly large number of strongly corroded yet identifiable sporomorphs. The following are the results of this analysis: *Pinus* t. *haploxylon* 63%, *Picea* 12%, *Abies* 11%, *Taxodium* 1%, *Sequoia* 3%, *Tsuga* 2%, *Podocarpus* 2%, *Castanea* 2%, *Carya* 1%, *Engelhardtia* 1%, *Magnoliaceae* 1%, *Diospyros* 1%, *Filicinae* 6%, *Gramineae* 1%, *Compositae* 1%, *Varia* 4%. This spectrum proves that an analysis of the „Gdów Bay" deposits by means of palynological methods is feasible and promising in its potential results.

This is confirmed by spore-pollen analysis of the drilling cores Kłaj 1 (Kita 1963). From 146 samples taken for analysis (70,6—84,2 m. depth range) only 19, coming from various depths, showed no sporomorphs. To the plant list of the „Gdów Bay" Miocene about 20 new forms were added, thanks to these analyses, among them a good number of spore-bearing plants (*Sphagnum, Equisetum,* cf. *Lycopodium, Polypodium, Aneimia, Cibotium, Mohria, Lygodium, Clathropteris, Dicksoniaceae*) as well as trees and shrubs (*Cedrus, Pterocarya, Castanopsis, Quercus, Nyssa, Rhus, Ilex, Symplocos, Tilia*).

LIST OF IDENTIFIED PLANTS

The results of palaeobotanical analysis of 41 samples coming from 16 localities of Tortonian deposits overlying the „Gdów Bay" have been compiled in a joint floristic list (Table 3). This joint treatment of all fossil material was necessary in view of the small number of identified plants in individual samples and of the impossibility of correlating them even in profiles situated close to one another. The exact localization of the identified plants is given in Table 2.

The floristic list contains results of macroscopic and palynological

analyses. It includes 93 forms [1] of which only 44 (43%) have specific identifications, the rest being identified less accurately.

The composition of the flora includes both trees and shrubs and small herbaceous plants, mosses, fungi and algae. The share of coniferous trees and shrubs amounts to 14%, of deciduous trees and shrubs to 35%, climbers 2%, herbaceous plants 29%, and spore-bearing plants to 20%. Coniferous trees undoubtedly showed greater variety than would appear from a numerical camparison since the genera *Abies* and *Pinus* were represented by several different species. It is also necessary to stress that the comparatively large share of herbaceous and spore-bearing plants (altogether about 50% of the total flora) is to a large extent linked with the meticulous investigation of the material under the microscope.

CHARACTERISTICS OF FOSSIL FLORA

It is by no means simple nor easy to reconstruct the picture of the vegetation on the basis of the obtained plant list. Above all, there are difficulties owing to the small number of identified species and to the many insufficiently accurate identifications. Moreover, it should be stressed that in all probability the entire plant material had been transported by water over greater or smaller distances (and, most certainly, also from various altitudes) and deposited in the sea. For this reason the flora of the „Gdów Bay" has an outstandingly mixed character as it contains elements of different plant communities evolved according to conditions of settlement and elevation above sea level.

The dominant role in these communities was played by various types of forest in which an important constituent were coniferous trees and shrubs which in higher positions were probably dominant. This is confirmed by their considerable generic differentiation, abundant in many profiles, macroscopic remains, and the pollen spectrum from Suchoraba in which the share of the genus *Pinus* amounted to 63%, *Picea* to 12%, and *Abies* to 11%. Similar conclusions are reached when the results of palynological investigations of the Kłaj 1 profile (K i t a 1963) are analysed, in which the percentage of coniferous trees is very high, amounting in some levels to as much as 90%. The composition of the flora indicates, additionally, its close connection with damp environments for it contains several indicators of both moist forest communities and tracts of open marshy land. Apart from higher plants there have also been preserved remains of fungi (in almost all the examined samples), of mosses, as well as of epiphytic algae.

[1] In the work entitled "Palaeobotanical investigations on the Miocene of Southern Poland" (Łańcucka-Środoniowa 1963) the number of 73 forms was given. At the conclusion of the investigations 20 new forms were added and some determinations altered.

Table 2
Tabela 2

Occurrence of macroscopic plant remains in geological profiles of the „Gdów Bay".
Abbreviations employed: fg = fragment; fr = fruit; s = seed; n = needle; l = leaf; st = stem; t = twig.
Występowanie szczątków makroskopowych roślin w profilach geologicznych „Zatoki Gdowskiej"
Stosowane skróty: fg = ułamek; fr = owoc; s = nasienie; n = szpilka; l = liść; st = łodyga; t = gałązka

	Locality Miejscowość	Sample No. Próba	Depth Głębokość	Lithological character of deposit Charakter litologiczny osadu	Results of palaeobotanical analysis Wyniki analizy paleobotanicznej
1	Bodzanów	1	surface sample	marl	wood, needles, leaf fragments
				silty sand	*Eucommia ulmoides* (fr, 2fg of l)
2	Kawki 1	2	64·8—70·8 m	gypsum	wood
		3	108·0 m	sand	wood, needle
3	Kawki 2	4	33·0—38·0 m	silt	wood
		5	180·0—184·0 m	sand	wood
		6	289·6 m	sand	wood
4	Bilczyce	7	13·4—19·6 m	sand	wood
5	Gdów	8—10	20·0—27·0 m (outcrop)	sand	*Epacridicarpum* cf. *mudense* (fr.)
6	Gdów 1	11, 12	135·7—142·0 m	sand	wood
7	Sypka Góra	13	surface sample	sand	*Glyptostrobus europaeus* (2t), *Sinomenium Militzeri* (fr) wood, fruits
8	Stadniki	14			wood

9	Liplas	15	38·8 m	sand	*Glyptostrobus europaeus* (6t, 21), *Rumex* sp. (fr) wood, fruits
		16	102—108 m	sand	*Carya* sp. (fr) wood
10	Wiatowice	17	259—265 m		wood
		18	265—271·4 m		wood
		19	394—402 m		wood
11	Suchoraba	20	27 m	sandy silt	*Abies* sp. (4n), *Fagus* aff. *orientalis* (fr), cf. *Arctostaphylos* sp. (fr) wood, stems of Monocotyledons, fruits
		21	135 m	sandy silt	*Actinomyces Alni* (2 specimens), *Abies* sp. (15n), *Glyptostrobus europaeus* (l), *Hellia salicornioides* (fg of t), *Carpinus* cf. *betulus* (fr) wood, needles, stems of Monocotyledons
		22	155 m	sandy silt	*Abies* sp. (13n), *Carpinus* cf. *betulus* (2fr), *Fagus* aff. *orientalis* (2fr), *Broussonetia tertiaria* (fr), *Carex* aff. *rostrata* (fr), *Schoenoplectus* aff. *Tabernaemontani* (fr) wood, needles, stems of Monocotyledons, fruits
		23	256—261 m	sandy mud	*Abies* sp. (5n), *Sparganium* cf. *camenzianum* (fr) wood, needles
		24	318—326·6 m	sand	*Actinomyces Alni* (2 specimens), cf. *Echinodium Savicziae* (t), *Abies* sp. (2n), *Glyptostrobus europaeus* (2fg of t and a cone), *Liquidambar* aff. *orientalis* (fg of fruiting head), *Liriodendron geminata* (s), *Cornus* sp. (fr), *Sparganium* cf. *camenzianum* (fr) wood, fruits
12	Cichawa	25	215—221 m	sandy silt	*Ampelopsis Ludwigii* (s), *Heleocharis* sp. (fr) wood, stems of Monocotyledons

	Locality Miejscowość	Sample No. Próba	Depth Głębokość	Lithological character of deposit Charakter litologiczny osadu	Results of palaeobotanical analysis Wyniki analizy paleobotanicznej
13	Pierzchów	26—28	149—177 m	sandy silt	*Actinomyces Alni* (1 specimen), cf. *Fungi Imperfecti*, *Eurhynchium Swartzii*, *Heterocladium squarrosulum*, *Ginkgo adiantoides* (fg of l), *Abies* sp. (6n), *Picea* sp. (n), *Pinus* sp. (n), *Thuja* aff. *occidentalis* (2fg of t), *Hellia salicornioides* (fg of t), *Betula* sect. *Albae* (fr), cf. *Phyllanthus* sp. (2s), *Potamogeton* aff. *pygmaeus* (fr), *Scirpus* aff. *silvaticus* (fr), *Antherites* (2 specimens) wood, leaf fragments, fruits
		29	183·3—188·6 m	sandy silt	cf. *Fungi Imperfecti*, *Anomodon longifolius*, *Cirriphyllum piliferum*, *Eurhynchium pulchellum*, *Taxodium distichum* (epidermis), cf. *Gramineae* (fr), *Antherites* (4 specimens) wood, leaf fragments, fruits, zoocecidiae
		30	189—210 m	sandy silt	*Actinomyces Alni* (3 specimens), *Pyrenomycetes* (2fg), *Eurhynchium* sp., cf. *Cephalotaxus* sp. (n), *Abies* sp. (10 apices of n, numerous fg), *Pinus* sp. (s, 2 short shoots, numerous fg of n), *Taxodium distichum* (2n), *Glyptostrobus europaeus* (2fg of t), *Acer* sp. 2, (fr), *Antherites* (1 specimen) wood, needles, stems of Monocotyledons, fruits, roots
		31	239—283 m	sandy silt	*Brachythecium* sp. wood, leaf fragments
14	Książnice	32	563—564·5 m	grey mud	*Taxodium distichum* (4n), *Glyptostrobus europaeus* (t and l), *Hellia salicornioides* (2fg of t), *Betula* sect. *Albae* (fr), *Liriodendron geminata* (2s), *Thalictrum* sp. (fr), *Eurya stigmosa* (s), *Rubus* cf. *microspermus* (2fr), cf. *Gramineae* (fr) wood, needles, stems of Monocotyledons, fruits, seeds

		33	571·1 m	sandy silt	wood, impression of a leaf
		34	666·4—671·5 m	sandy silt	*Lemna* sp. (s) wood, needles, leaf fragments, stems of Monocotyledons, fruits, roots
15	Kłaj	35	231·3—237·3 m	grey sandstone	*Polyporites* sp. (fg of hymenium) wood, fruits
		36	272—279 m	marly silt	roots
		37	320—326 m	sandy silt	*Eurya stigmosa* (s)
		38	326—333 m	marly silt	wood, leaf fragments
		39	345—353·3 m	silty mud	*Abies* sp. (7n), *Pinus* sp. (2n, a short shoot), *Rubus* cf. *microspermus* (fr), *Carex* sp. 1 (fr), cf. *Cyperus* sp. (fr) wood, needles, stems of Monocotyledons, fruits, seeds, roots
		40	384·5—389 m	grey silt	*Musci* (2t and l), *Ginkgo adiantoides* (3fg of l), *Buxus sempervirens* (l), *Typha* cf. *elongata* (s) wood, leaf fragments
		41	499·4—501·9 m	grey silt	*Phycopeltis microthyrioides* (8 specimens), cf. *Fungi Imperfecti*, *Pinus* sp. (n), *Antherites* (1 specimen) wood, needles, leaf fragments, stems of Monocotyledons, fruits, cocoons of insects
		42	584·2—587·3 m	silt	*Neckera* sp. leaf fragments
		43	587·3—593·4 m		impression of a twig (4 cm)
		44	608·1—611·9 m	grey silt	cf. *Cephalotaxus* sp. (epidermis of n), *Scrophulariaceae* (s), cf. *Artemisia* sp. (fr), *Antherites* (2 specimens) leaf fragments, stems of Monocotyledons, fruits
		45	612·5—616·1 m	marly silt	wood, leaf fragments, needles

Tab. 2 c. d.

	Locality Miejscowość	Sample No. Próba	Depth Głębokość	Lithological character of deposit Charakter litologiczny osadu	Results of palaeobotanical analysis Wyniki analizy paleobotanicznej
15	Kłaj	46	616·1—621·8 m	grey silt	cf. *Fungi Imperfecti*, *Selaginella pliocaenica* (megaspore), *Pinus* sp. (2n), *Thuja* cf. *occidentalis* (fg of t), *Juniperus* sp. (n), *Ampelopsis Ludwigii* (s), cf. *Primulaceae* (s), *Typha* cf. *elongata* (s), *T.* aff. *maxima* (s) wood, needles, leaf fragments, stems of Monocotyledons, fruits and seeds
		47	632·2—639·6 m	sandstone	impressions of leaf fragments
		48	639·6—644·6 m	marl	wood, unidentifiable detritus
		49	644·6—648·7 m	silt	cf. *Fungi Imperfecti*, *Trematosphaerites lignitum* (2 peritheciae), *Pinus* sp. (n), *Buxus sempervirens* (fg of l), *Typha* aff. *maxima* (s) needles, leaf fragments
		50	648·7—654·2 m	marl	wood, unidentifiable detritus
		51	657·1—670 m	silt	*Phycopeltis microthyrioides* (2 specimens), cf. *Fungi Imperfecti*, *Hellia salicornioides* (fg of t), *Typha* cf. *elongata* (s) wood, leaf fragments, fruits
		52	683·9—697 m	sandy mud	*Selaginella pliocaenica* (fg of megaspore) wood, leaf fragments, stems of Monocotyledons, fruits
		53	706·1—711·9 m	sandy mud	*Thuja* cf. *occidentalis* (fg of t), *Hellia salicornioides* (fg of t), *Juncus* sp. (s), *Gramineae* (3fr) wood, leaf fragments, stems of Monocotyledons, fruits
		54	733·4—738·9 m	sandy silt	wood, leaf fragments
		55	738·9—744·8 m	silt	cf. *Fungi Imperfecti*, *Brachythecium velutinum*, *Thamnium alopecurum*, *Neckera* sp., *Abies*. (7n), *Glyptostrobus europaeus*

					(3fg of t, l), *Labiatae* (2fr), Gramineae (fr), *Antherites* (4 specimens) wood, needles, leaf fragments, stems of Monocotyledons, fruits, roots
		56	744·8—750·4 m	marly silt	leaf fragments, roots
		57	764·1—768 m	marly sandish silt	cf. *Fungi Imperfecti*, *Abies* sp. (n), *Hellia salicornioides* (fg of t), *Thalictrum* sp. (fr), *Rubus* cf. *microspermus* (5fr), cf. *Gramineae* (fr) wood, needles, leaf fragments, stems of Monocotyledons, fruits
16	Siedlec 3	58	305·8—314 m	sand	*Abies* sp. (4fg of n), *Hellia salicornioides* (fg of t), cf. *Ficus carica* (fr), *Acer* sect. *Palmata* (fr), *Aralia* sp. (fr) wood, needles, fruits
		59	314—320 m		wood
		60	739—747 m		wood
		61	941·9—950·6 m	sandy silt	wood
17	Siedlec 4	62	464—468 m	sandy silt	cf. *Fungi Imperfecti*, *Broussonetia pygmaea* (fr), *Antherites* (1 specimen) wood, leaf fragments
		63	497·6—503·2 m	sandy silt	cf. *Fungi Imperfecti*, *Abies* sp. (3n+7fg), *Hellia salicornioides* (fg of t), *Actinidia faveolata* (s), cf. *Rubus* sp. (thorn), *Schoenoplectus* sp. 1 (3fr), *Schoenoplectus* sp. 2 (2fr), cf. *Gramineae* (2fr), *Typha* aff. *pusilla* (s), *Antherites* (4 specimens) wood, needles, stems of Monocotyledons, fruits, seeds, roots
		64	560—599 m	sandy silt	*Abies* sp. (n), *Betula* sect. *Albae* (fr), *Corylus* sp. (fr), *Carex* sp. 3 (fr) wood, needles, stems of Monocotyledons, fruits
18	Chełm	65	surface sample		cf. *Fungi Imperfecti* wood

Tab. 2 c. d.

	Locality Miejscowość	Sample No. Próba	Depth Głębokość	Lithological character of deposit Charakter litologiczny osadu	Results of palaeobotanical analysis Wyniki analizy paleobotanicznej
19	Gierczyce	66	556·0—562·0 m	silty sand	cf. *Actinomyces Alni* (1 specimen), *Abies* sp. (n), *Carpinus* cf. *betulus* (fr), *Sinomenium Militzeri* (fr) wood, fruits
		67	648—654 m	sandy silt	wood
20	Łapczyca 1	68	448—453 m	sandstone	sample not examined
		69	618—625 m		wood
		70	643—655 m	sand	*Carpinus* cf. *betulus* (fr), *Sambucus* sp. (s) wood
		71	727—730 m	sandy silt	traces of detritus
		72	810·5 m	sandy silt	wood
21	Łapczyca 2	73	618—625 m	grey silt	*Coniferae* (3 charcoals)
		74	867—874 m	sandy silt	*Eurya stigmosa* (2n), *Aralia* aff. *hispida* (fr), *Compositae* (fr), *Potamogeton* cf. *heinkei* (fr), *Carex* sp. 2 (fr), *Aracispermum canaliculatum* (4s) wood, fruits
22	Dąbrowica	75	227—425·5 m	sandy silt	wood
		76	238—442 m	sandy silt	*Abies* sp. (n), *Sambucus* sp. (s) wood, stems of Monocotyledons
		77	386—389 m	sandy silt	wood
23	Kolanów	78	194·6—199·4 m	bottom conglomerate	wood
24	Bochnia	79	798·3—799·5 m	sandy silt	wood, traces of detritus
		80	801·3—802·6 m	sandstone	traces of detritus

Plant communities

The fossil flora of „Gdów Bay" represents several different habitats and plant communities whose probable constituents are set out in Table 4. They were communities of water and swamp plants and of lower and higher mountain levels. In lower positions there occurred damp forests and thickets covering river banks and the waterlogged bottoms of mountain valleys. Higher, on well-drained slopes, there grew the most luxuriant deciduous forests with an admixture of coniferous trees. Amidst these forests there were probably drier habitats and, perhaps, rockier ones with a flora of a somewhat different nature. It is very likely that there grew here plants such as *Aralia* aff. *hispida*, *Arctostaphylos*, and *Artemisia*. Slopes situated yet higher were overgrown by mixed and coniferous forests not so conspicuous in the obtained material as the forests of the lower stage. Among deciduous trees there may have occurred here beeches (*Fagus* aff. *orientalis*) and maples similar to the eastern Asiatic species *Acer ukurunduense*. Also, it is possible with this stage alone to connect the remains of the arctic-alpine moss *Heterocladium squarrosulum*.

Geographical elements

The distinction of geographical elements which occur in the flora of „Gdów Bay" was possible only on the basis of those fossil plants which are similar to, or almost identical with, contemporary species. From the number of 41 taxons it was necessary to exclude the mosses, the genus *Juncus*, the family of *Cyperaceae* and *Typha* cf. *elongata* in view of their very wide geographical distribution. For the sake of simplicity, only three main regions of contemporary flora have been taken into account, i.e. North America, Eastern Asia, and Eurasia from which has been distinguished a broadly defined South Mediterranean region (together with Asia Minor, the Caucasus, Syria, and Iran).

From the distribution of contemporary species related to the „Gdów Bay" flora set out in Table 5 it appears that the majority of fossil flora consists of plants connected with Europe and Asia since relationship with East Asiatic species is shown by 16 forms (59%), with Eurasian by 2 forms (7,4%) and with Mediterranean ones by 7 forms (26%). Only 6 fossil forms (22%) in the examined flora are connected with North American species.

Worthy of stress is the large share of plants related to species from Eastern Asia and Asia Minor which once again confirms the well-known and frequently described extremely wide range of these plants in the Tertiary.

Table 3
Tabela 3

List of identified plants from the Tortonian of the „Gdów Bay".
Crosses represent macroscopic remains and circles sporomorphs.
Lista roślin oznaczonych z tortonu „Zatoki Gdowskiej"
Krzyżyki oznaczają szczątki makroskopowe, a kółka sporomorfy

Names of stations and their successive numbers on map (Fig. 1) / Nazwy stanowisk i ich numery kolejne na mapie / Identification of taxonomical units / Oznaczenie jednostek taksonomicznych		1 Bodzanów	5 Gdów	7 Sypka Góra	9 Liplas	11 Suchoraba 1	12 Cichawa 1	13 Pierzchów 1	14 Książnice 1	15 Kłaj 1	16 Siedlec 3	17 Siedlec 4	18 Chełm	19 Gierczyce	20 Łapczyca 1	21 Łapczyca 2	22 Dąbrowica
1	*Actinomyces Alni* Harz					+		+						+			
2	*Phycopeltis microthyrioides* Kirchh.									+							
3	cf. *Fungi Imperfecti*							+		+		+	+				
4	*Trematosphaerites lignitum* (Heer) Mesch.									+							
5	*Pyrenomycetes*							+									
6	*Polyporites* sp.									+							
7	*Neckera* sp.									+							
8	*Thamnium alopecurum* Br. eurp.									+							
9	*Echinodium Savicziae* A. J. Abr.					+											
10	*Anomodon longifolius* Bruck.							+									
11	*Heterocladium squarrosulum* Lindb.							+									
12	*Brachythecium velutinum* Br. curp.									+							
13	*Brachythecium* sp.							+									
14	*Cirriphyllum piliferum* Grout.							+									
15	*Eurhynchium pulchellum* Dix.							+									
16	*Eurhynchium Swartzii* Curr.							+									
17	*Eurhynchium* sp.							+									
18	*Selaginella pliocaenica* Dorof.									+							
19	*Filicinae*					○											

20	*Ginkgo adiantoides* (Ung.) Heer							+		+							
21	*Podocarpus*					○											
22	cf. *Cephalotaxus* sp.							+		+							
23	*Abies alba* Mill. s. l.					+		+		+	+						
24	*Abies* sp. div.					⊕		+			+	+		+			+
25	*Tsuga*					○											
26	cf. *Picea* sp.					○		+									
27	*Pinus* sect. *Taeda* Spach.							+									
28	*Pinus* sp. div.					○		+		+							
29	*Sequoia*					○											
30	*Taxodium distichum miocaenicum* Heer					○		+	+								
31	*Glyptostrobus europaeus* Heer			+	+	+		+	+	+							
32	*Thuja* aff. *occidentalis* L.							+		+							
33	*Hellia salicornioides* Ung.					+		+	+	+	+	+					
34	*Juniperus* sp.									+							
35	*Betula* sect. *Albae*							+	+			+					
36	*Carpinus* cf. *betulus* L.					+								+	+		
37	*Corylus* sp.											+					
38	*Castanea*					○											
39	*Fagus* sp. (aff. *orientalis* Lipsky)					+											
40	*Carya* sp.				+	○											
41	*Engelhardtia*					○											
42	*Broussonetia tertiaria* Dorof.					+											
43	*Broussonetia pygmaea* Dorof.											+					
44	cf. *Ficus carica* L.										+						
45	*Eucommia ulmoides* Oliv.	+															
46	*Rumex* sp.				+												
47	cf. *Phyllanthus* sp.							+									
48	*Buxus sempervirens* L. foss.									+							
49	*Liquidambar* aff. *orientalis* Miller					+											
50	*Liriodendron geminata* Kirchh.					+			+								
51	*Magnoliaceae*					○											
52	*Sinomenium Militzeri* Kirchh.			+										+			

	Names of stations and their successive numbers on map (Fig. 1) / Nazwy stanowisk i ich numery kolejne na mapie / Identification of taxonomical units / Oznaczenie jednostek taksonomicznych	1 Bodzanów	5 Gdów	7 Sypka Góra	9 Liplas	11 Suchoraba 1	12 Cichawa 1	13 Pierzchów 1	14 Książnice 1	15 Kłaj 1	16 Siedlec 3	17 Siedlec 4	18 Chełm	19 Gierczyce	20 Łapczyca 1	21 Łapczyca 2	22 Dąbrowica
53	*Thalictrum* sp.								+	+							
54	*Actinidia faveolata* C.-E. M. Reid											+					
55	*Eurya stigmosa* (Ludw.) Mai								+	+						+	
56	*Rubus* cf. *microspermus* C.-E. M. Reid								+	+							
57	*Rubus* sp.											+					
58	*Acer* sect. *Palmata* Pax										+						
59	*Acer* sect. *Spicata* Pax							+									
60	*Ampelopsis Ludwigii* (A. Br.) Dorof.						+			+							
61	*Cornus* sp.					+											
62	*Aralia* aff. *hispida* Vent.															+	
63	*Aralia* sp.										+						
64	cf. *Primulaceae*									+							
65	cf. *Arctostaphylos* sp.					+											
66	*Epacridicarpum* cf. *mudense* Chandler		+														
67	*Scrophulariaceae*									+							
68	*Diospyros*					○											
69	*Labiatae* gen. div.									+							
70	*Sambucus* sp.														+		+
71	cf. *Artemisia* sp.									+							
72	*Compositae* gen. div.					○										+	
73	*Potamogeton* aff. *pygmaeus* Reid							+									
74	*Potamogeton* cf. *heinkei* Mai															+	
75	*Juncus* sp.									+							

76	*Carex* aff. *rostrata* Stokes					+											
77	*Carex* sp. 1									+							
78	*Carex* sp. 2															+	
79	*Carex* sp. 3											+					
80	cf. *Cyperus* sp.									+							
81	*Scirpus* cf. *silvaticus* L.							+									
82	*Schoenoplectus* aff. *Tabernaemontani* (Gmel.) Palla					+											
83	*Schoenoplectus* sp. 1											+					
84	*Schoenoplectus* sp. 2											+					
85	*Heleocharis* sp.						+										
86	*Gramineae* gen. div.					○		+	+	+		+					
87	*Lemna* sp.								+								
88	*Aracispermum canaliculatum* Nikit.															+	
89	*Sparganium* cf. *camenzianum* Kirchh.					+											
90	*Typha* cf. *elongata* Dorof.									+							
91	*Typha* aff. *maxima* Dorof.									+							
92	*Typha pusilla* Dorof.											+					
93	*Antherites*							+		+		+					
	total	1	1	2	3	30	2	27	10	31	6	13	1	4	2	6	2

Table 4
Tabela 4

Groups of plant communities represented in the Tortonian flora of the „Gdów Bay".
Grupy zbiorowisk roślinnych reprezentowanych we florze tortońskiej „Zatoki Gdowskiej"

Groups of plant communities / Grupy zbiorowisk roślinnych — Names of plants / Nazwy roślin	Aquatic vegetation / Roślinność wodna	Swamp vegetation / Roślinność bagienna	Mixed forest in lower mountain altitudes / Lasy mieszane niższych położeń górskich			Mixed forests of higher mountain altitudes. Lasy mieszane wyższych położeń górskich
			Valleys and wet banks of rivers. Doliny i wilgotne brzegi rzek	Mountain slopes / Stoki górskie	Vegetation of dry rocky localities / Roślinność suchych skalnych miejsc	
Potamogeton aff. *pygmaeus*	+					
Potamogeton cf. *heinkei*	+					
Lemna sp.	+					
Typha cf. *elongata*		+				
Typha aff. *maxima*		+				
Typha pusilla		+				
Juncus sp.		+				
Taxodium distichum miocaenicum		+				
Sparganium cf. *camenzianum*		+				
Aracispermum canaliculatum		+				
cf. *Cyperus* sp.		+				
Heleocharis sp.		+				
Schoenoplectus aff. *Tabernaemontani*		+				
Scirpus cf. *silvaticus*		+	+			
Carex aff. *rostrata*		+	+			
Glyptostrobus europaeus		+	+			
Alnus (Actinomyces Alni)			+	+		
Cornus sp.			+			
Aralia sp.			+			
Ampelopsis Ludwigii			+			
Thamnium alopecurum			+			
Sinomenium Militzeri			+			
Thuja aff. *occidentalis*			+	+		
Liquidambar aff. *orientalis*			+	+		
Acer sect. *Palmata*			+	+		
Sambucus sp.			+	+		
Buxus sempervirens			+	+		
cf. *Phyllanthus* sp.			+	+		
Actinidia faveolata			+	+		
Eurya stigmosa				+		

Tab. 4 c. d.

Groups of plant communities / Grupy zbiorowisk roślinnych — Names of plants / Nazwy roślin	Aquatic vegetation Roślinność wodna	Swamp vegetation Roślinność bagienna	Mixed forest in lower mountain altitudes Lasy mieszane niższych położeń górskich: Valleys and wet banks of rivers. Doliny i wilgotne brzegi rzek	Mixed forest in lower mountain altitudes: Mountain slopes Stoki górskie	Mixed forest in lower mountain altitudes: Vegetation of dry rocky localities. Roślinność suchych skalnych miejsc	Mixed forests of higher mountain altitudes Lasy mieszane wyższych położeń górskich
Liriodendron geminata				+		
Broussonetia tertiaria				+		
Broussonetia pygmaea				+		
Ginkgo adiantoides				+		
Carya sp.				+		
Betula sect. *Albae*						
Abies sp. div.				+		
Carpinus cf. *betulus*				+		
cf. *Ficus carica*				+		
Eucommia ulmoides				+		
Anomodon longifolius				+		
Echinodium Savicziae				+		
Eurhynchium Swartzi				+		
Cirriphyllum piliferum				+		
Brachytecium velutinum				+		
Corylus sp.				+	+	
Fagus aff. *orientalis*				+		+
Acer sect. *Spicata*				+		+
Pinus sp. div.				+		+
cf. *Picea* sp.				+		+
Eurhynchium pulchellum				+		+
Aralia aff. *hispida*					+	
cf. *Arctostaphylos* sp.					+	
cf. *Artemisia*					+	
cf. *Cephalotaxus* sp.						+
Juniperus sp.						+
Heterocladium squarrosulum						+

Table 5

Tabela 5

Distribution of contemporary species related to the flora of the „Gdów Bay". Species in brackets show remoter relationship.
Rozmieszczenie współczesnych gatunków pokrewnych z florą „Zatoki Gdowskiej". Gatunki umieszczone w nawiasach wykazują dalszy stopień pokrewieństwa

Fossil plants of the „Gdów Bay" Rośliny kopalne „Zatoki Gdowskiej"	Related contemporary species Pokrewne gatunki współczesne			
	North America Ameryka Północna	East Asia Azja Wschodnia	Eurasia Eurazja	The Mediterranean Obszar Śródziemnomorski
Thamnium alopecurum		*T. alopecurum*	*T. alopecurum*	*T. alopecurum*
Anomodon longifolius			*A. longifolius*	*A. longifolius*
Heterocladium squarrosulum	*H. squarrosulum*		*H. squarrosulum*	*H. squarrosulum*
Brachythecium velutinum	*B. velutinum*		*B. velutinum*	*B. velutinum*
Cirriphyllum piliferum	*C. piliferum*		*C. piliferum*	*C. piliferum*
Eurhynchium pulchellum	*E. pulchellum*		*E. pulchellum*	*E. pulchellum*
Eurhynchium Swartzii	*E. Swartzii*		*E. Swartzii*	*E. Swartzii*
Selaginella pliocaenica	*(S. apoda, S. densa)*			
Ginkgo adiantoides		*G. biloba*		
cf. *Cephalotaxus* sp.		*Cephalotaxus* sp. div.		
Abies alba s. l.			*A. alba*	
Abies sp. div.		*A. nephrolepis, homolepis*		
Taxodium distichum miocaenicum	*T. distichum*			
Glyptostrobus europaeus		*G. pensilis*		
Thuja aff. *occidentalis*	*T. occidentalis*	*(T. protojaponica)*		

Carpinus cf. *betulus*			*C. betulus*	
Fagus aff. *orientalis*				*F. orientalis*
Broussonetia tertiaria		*B. papyrifera*		
Broussonetia pygmaea		*B. Kazinoki*		
cf. *Ficus carica*				*F. carica*
Eucommia ulmoides		*E. ulmoides*		
cf. *Phyllanthus*		*(P. emblica)*		
Buxus sempervirens				*B. sempervirens*
Liquidambar aff. *orientalis*				*L. orientalis*
Sinomenium Militzeri		*S. acutum*		
Actinidia faveolata		*A. Kolomikta*		
Eurya stigmosa		*(E. japonica)*		
Acer sect. *Palmata*		*(A. palmatum)*		
Acer sect. *Spicata*		*(A. ukurunduense)*		
Ampelopsis Ludwigii		*A. Watsoniana, leoides*		*A. orientalis*
Cornus sp.	*C. femina, stricta*			
Aralia aff. *hispida*	*A. hispida*			
cf. *Arctostaphylos* sp.	*Arctostaphylos* sp. div.			
Potamogeton aff. *pygmaeus*		*P. cristatus*		
Juncus sp.	*(J. bulbosus)*		*(J. bulbosus)*	*(J. bulbosus)*
Carex aff. *rostrata*	*C. rostrata*	*C. rostrata*	*C. rostrata*	*C. rostrata*
cf. *Cyperus* sp.	*(C. rotundus)*	*(C. rotundus)*	*(C. longus)*	*(C. longus)*
Scirpus cf. *silvaticus*	*(S. silvaticus* var. *Bissellii*	*S. silvaticus*	*S. silvaticus*	*S. silvaticus*
Schoenoplectus aff. *Tabernaemontani*		*S. Tabernaemontani*	*S. Tabernaemontani*	*S. Tabernaemontani*
Heleocharis sp.	*(H. pauciflora)*		*(H. pauciflora)*	*(H. pauciflora)*
Typha cf. *elongata*	*(T. latifolia, angustifolia)*	*(T. latifolia)*	*(T. latifolia, angustifolia)*	*(T. latifolia, angustifolia)*

Remarks on climate

The mixed character of the flora is probably reason why we find in it indicators of various types of climate from a moderately warm and damp (*Taxodium*, *Phycopeltis* [1], *Echinodium Savicziae* [2], *Phyllanthus*) to a moderately cool one which at that time prevailed in higher mountainous levels (*Coniferae*, *Heterocladium squarrosulum*).

The majority of plants point to a mildly temperate climate, somewhat warmer and damper than that contemporary one in this region. It was a climate favourable to the development of luxuriant and compositionally differentiated broad-leaf deciduous forests as well as equally luxuriant mixed forests.

The flora under discussion lacks indicators of a dry climate, there are only a few plants from distinctly dry habitats: *Aralia* cf. *hispida*, cf. *Arctostaphylos* sp., cf. *Artemisia* sp.

COMPARISON WITH OTHER MIOCENE FLORAS OF SOUTHERN POLAND

The flora of the „Gdów Bay" stands in a close stratigraphical relationship with the neighbouring floras of Wieliczka and Swoszowice which come from the gypsum-saline level. From the above-mentioned three floras that of the „Gdów Bay" covers the longest span of time as it derives from deposits lying both under and over the gypsum-saline level (cf. the stratigraphical scheme on page 6). For this reason it is also bound up, and distinctly so, with the somewhat younger flora from Stare Gliwice in Upper Silesia.

A comparison between the vegetation of the above-mentioned localities necessitates, however, the making of a number of reservations deriving above all from differences in material. Swoszowice contains exclusively leafy flora while Wieliczka and the „Gdów Bay" are represented above all by fruits and seeds. Of the existing material from Wieliczka only a part containing predominantly large size remains has been so far described which does not portray the flora adequately and a good many remains from the „Gdów Bay" could not be identified specifically. The luxuriant flora of Stare Gliwice, containing plants described on the basis of both large and small remains, relatively most closely resembles that of the „Gdów Bay", as far as the type of material is concerned, not to

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[1] The species *Phycopeltis epiphyton* is today widespread in the tropical jungle of the intertropical zone but the fossil species *P. microthyrioides* has been found on the leaves of a typically Mediterranean plant, the *Buxus sempervirens* (Szafer 1961).

[2] Related species grow today in New Zealand (*E. hispidum*) and on Madeira and the Azores (*E. Renauldi* and *E. spinosum*).

mention the fact that it was possible to subject the two floras to fuller treatment with the help of the results of palynological investigations.

An attempt to assemble forms common to the flora of „Gdów Bay" and those of Wieliczka, Swoszowice, and Stare Gliwice is set out in Table 6.

From a comparison of common species, some characteristic genera, or families, it would appear that the flora of the „Gdów Bay" shares most common elements with the flora of Stare Gliwice, somewhat fewer with that of Wieliczka and least with that of Swoszowice.

Such a picture, inconsistent with the stratigraphical position of considered floras, arises from the differences in material to which reference has already been made. Another contributory factor is that almost all the „common species" are plants which occurred in the European Tertiary over a fairly long space of time and thus have relatively small stratigraphical significance. Among these species only *Eurya stigmosa* (Ludw.) Mai, identified in the „Gdów Bay" and Wieliczka has so far been unknown to occur in European deposits younger than the Middle Miocene.

The quite considerable similarity of the vegetation of the „Gdów Bay" and Stare Gliwice diminishes when one analyses individual common genera containing in both these floras various species, sometimes distinctly „older" in the case of the „Gdów Bay" (*Rubus* cf. *microspermus*, *Potamogeton* aff. *pygmaeus*, *P. heinkei*, *Sparganium* cf. *camenzianum*).

Although in the flora of the „Gdów Bay" it was impossible to identify the of *Lauraceae* or *Mastixioideae* characteristic of the Middle Miocene families (large specimens are very rarely preserved in small samples coming from drilling cores) yet this flora includes several small forms which had hitherto been found almost exclusively in Paleogene and Miocene deposits but not in those younger than the Middle Miocene as, for instance, *Eurya stigmosa*, *Rubus* cf. *microspermus*, *Epacridicarpum* cf. *mudense*, *Potamogeton* aff. *pygmaeus*, *P.* cf. *heinkei*, *Sparganium* cf. *camenzianum*.

TENTATIVE STRATIGRAPHICAL CLASSIFICATION OF THE TORTONIAN ON THE BASIS OF FLORA

It might be asked whether on the floristic basis alone it is possible to distinguish in the flora of the „Gdów Bay" the two substages of the Tortonian, i.e. the Lower and Upper Tortonian. Both these substages, differentiated on the basis of geological criteria, occur in the Kłaj 1 profile from which plant remains have been identified in 10 samples of Upper Tortonian deposits (231—697 m.) and in 3 samples of Lower Tortonian ones (706—768 m.).

A comparison of the results of macroscopic analysis of the Kłaj 1 profile does not, however, show the anticipated differences (Fig. 4). In the two substages there are several common forms: some which are solely

Table 6
Tabela 6

List of plant taxons common to the flora of the „Gdów Bay" and the floras of Wieliczka, Swoszowice and Stare Gliwice.

Explanation of signs: + = macroscopic remains; (+) = forms described under a different name or inaccurately determined; o = sporomorphs; * = sporomorphs established in the profile of Kłaj 1 (Kita 1963).

Zestawienie taksonów wspólnych między florą „Zatoki Gdowskiej" a florami Wieliczki, Swoszowic i Starych Gliwic

Objaśnienie znaków: + = szczątki makroskopowe; (+) = formy opisane pod inną nazwą lub niedokładnie oznaczone; o = sporomorfy; * = sporomorfy stwierdzone w profilu Kłaj 1 (Kita 1963)

Names of localities / Nazwy miejscowości Names of plants / Nazwy roślin	„Gdów Bay" „Zatoka Gdowska"	Wieliczka	Swoszowice	Stare Gliwice	
Phycopeltis microthyrioides	+			+	
Trematosphaerites lignitum	+	+			
Ginkgo adiantoides	+			+	
Abies alba s. l.	+			+	
Sequoia Langsdorfii	(o)	+	+	+	
Taxodium distichum miocaenicum	+	+	+	+	
Glyptostrobus europaeus	+	+		+	
Hellia salicornioides	+	+		+	
Betula sect. *Albae*	+			+	
Carpinus cf. *betulus*	+	+	(+)	+	Common species
Fagus aff. *orientalis*	+	+	(+)	+	Wspólne gatunki
Eucommia ulmoides	+	(+)		+	
Buxus sempervirens	+			+	
Liquidambar aff. *orientalis*	+	+		+	
Liriodendron geminata	+	(+)		+	
Sinomenium Militzeri	+			+	
Eurya stigmosa	+	+			
Acer sect. *Palmata*	+			+	
Ampelopsis Ludwigii	+	+		+	
Typha aff. *maxima*	+			+	
Cephalotaxus	+			+	
Abies sp. div.	+			+	
Picea	+			+	
Pinus sp. div.	+	+		+	
Juniperus	+			+	
Alnus	(+)	+	+	+	Common genera
Corylus	+			+	Wspólne rodzaje
Castanea	o	+	+	+	
**Castanopsis*	o	+		+	
**Quercus*	o	+	+	+	
Carya	+	+		+	

Tab. 6 c. d.

Names of localities / Nazwy miejscowości Names of plants / Nazwy roślin	„Gdów Bay" „Zatoka Gdowska"	Wieliczka	Swoszowice	Stare Gliwice	
**Pterocarya*	o	+	+	+	
Engelhardtia	o	+		o	
Thalictrum	+			+	
Actinidia	+	+		+	
Rubus	+			+	
**Nyssa*	o	+			
**Tilia*	o	+		+	
**Rhus*	o		+	o	Common genera
**Ilex*	o			+	Wspólne rodzaje
Aralia	+	+	+	+	
Diospyros	o	+	+		
**Symplocos*	o	+		+	
Sambucus	+	+		+	
Potamogeton	+			+	
Schoenoplectus	+			+	
Carex	+	+		+	
Sparganium	+			+	
Pinaceae	+	+		+	
Taxodiaceae	+	+	+	+	
Cupressaceae	+	+		+	
Juglandaceae	+	+	+	+	Common families
Magnoliaceae	+	+		+	Wspólne rodziny
Labiatae	+			+	
Cyperaceae	+	+		+	
Gramineae	+		+		

„Upper Tortonian" in Kłaj, in other profiles occur in Lower Tortonian deposits. There are also a few forms which have been found only in the Upper Tortonian of Kłaj (*Juniperus, Selaginella pliocaenica, Buxus sempervirens, Scrophulariaceae, Primulaceae, Artemisia, Cyperus, Carex sp.* 1, *Typha elongata, T. maxima*), but this is rather unlikely to have any stratigraphical significance. *Buxus sempervirens,* known from the Sarmatian and Pliocene floras of Europe, occurs also in the Middle Miocene flora of Zaleśce (C z e c z o t t o w a 1951), the genus *Juniperus* has been found in Wieliczka (Prof. Z a b ł o c k i's lecture, 1957) and the seeds of *Typha elongata* and *T. maxima* as well as remains of the genus *Cyperus* and fruits of various species of *Carex* are known from the older deposits of the European and Western Siberian Tertiary.

The results of palynological analysis of the Kłaj 1 profile (K i t a 1963)

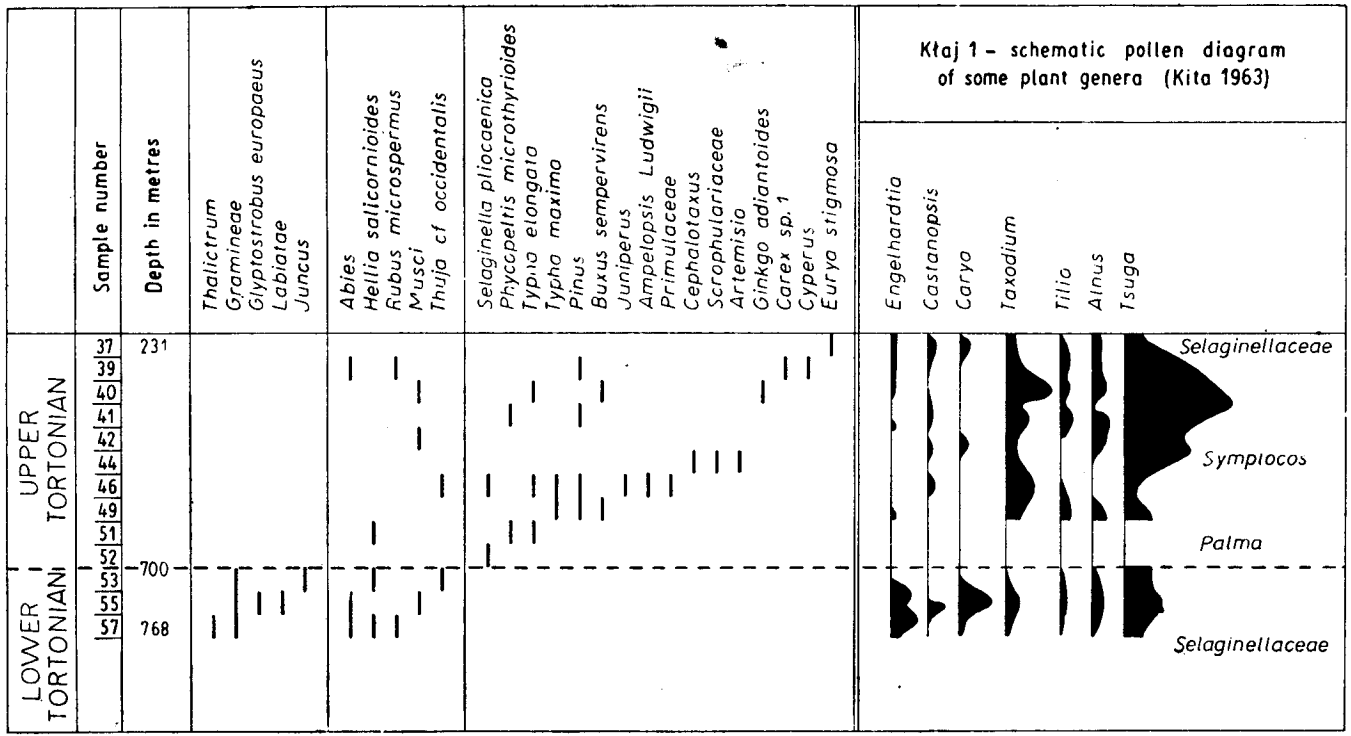

Fig. 4. Results of macroscopic and microscopic investigations of Tortonian deposits of Kłaj 1 profile.
Ryc. 4. Wyniki badań paleobotanicznych (makroskopowych i mikroskopowych) nad osadami tortońskimi profilu Kłaj 1

furnish, perhaps, some basis for the differentiation of these two stages. Although the course of curves in the diagram is somewhat monotonic and featureless yet the larger share of the genera *Carya, Engelhardtia,* and *Castanopsis* (found in one sample only) is clearly discernible in the Lower Tortonian spectrum and of the genera *Taxodium, Tsuga, Alnus,* and *Tilia* in the Upper Tortonian one (cf. Fig. 4). These differences are, on the whole, in accordance with the optimal occurrence of the above-mentioned genera in Neogene profiles.

The difference between the vegetation of the Lower and Upper Tortonian is relatively best seen when account is taken of plants representing the „oldest" element (Table 7).

Table 7
Tabela 7

„Oldest" forms in Tortonian flora from the „Gdów Bay".
Formy „najstarsze" we florze tortońskiej „Zatoki Gdowskiej"

The Lower Tortonian: Gdów, Suchoraba, Pierzchów, Książnice, Kłaj 1, Łapczyca 2	The Upper Tortonian: Kłaj 1
Eurya stigmosa	*Eurya stigmosa*
Rubus cf. *microspermus*	*Rubus* cf. *microspermus*
Epacridicarpun cf. *mudense*	
Potamogeton aff. *pygmaeus*	
Potamogeton cf. *heinkei*	
Sparganium cf. *camenzianum*	

The plants belonging to this element have all been found in Lower Tortonian deposits coming from 6 stations, only two of them occurring also in Upper Tortonian deposits. It should be stressed, however, that even this seemingly rather clear, difference cannot be unreservedly accepted since the number of Upper Tortonian samples examined was too small. It may be that future studies of these palaeobotanically little known deposits will throw more light on this matter.

In the present state of our knowledge on the Tortonian vegetation of the foreland of the Carpathians it is difficult to determine the boundary between the Lower and Upper Tortonian on a palaeobotanical basis alone. It would seem that variations in the character of the vegetation in the time of the entire Tortonian were relatively insignificant, which would indicate that the climate of that period underwent no important transformations.

II. TAXONOMIC PART

SCHIZOMYCETES

Actinomyces Alni Harz

Fig. 5, *1, 2*

Localities: Suchoraba 21, 24; Pierzchów 26, 30; Gierczyce 66[1]

In five samples 9 small fragments of roots of alder with characteristic thickenings due to the presence of bacteria of the genus *Actinomyces* were found. Root fragments are small (3—6 mm.), compressed, quite frequently dichotomically furcated. Similar remains have been described by W. S z a f e r from the Pliocene of Krościenko (1947) and from the Miocene at Stare Gliwice (1961).

ALGAE

Trentepohliaceae

Phycopeltis microthyrioides Kirchh.

Pl. I. *1—4*

Locality: Kłaj 41, 51

On small fragments of leaves or their epidermis the presence of epiphytic algae from the genus *Phycopeltis* was confirmed. Altogether some 20 specimens of this algae in the form of yellow-brown spots 10—144 μ in diameter have been preserved. Shield-like algae have a single-layer thallus consisting of fairly regular rows of cells diverging radially towards the centre. These cells, especially in the peripheral part, are rectangular in shape and adhere closely to one another. In the middle of the thallus

[1] Figures by the names of localities indicate numbers of individual samples.

the cells are considerably shorter, polygonal, and somewhat rounded. The thallus is almost circular in shape, in larger specimens its margin being slightly wavy. In one well-developed thalius (Pl. I, *3*) can be seen 2 small apertures which are traces of gametangia.

In some leaf fragments can be seen further developmental stages of the alga described above. They are dark, globular spots of various sizes dispersed among veins (Pl. I, *4*).

These small shield-like algae are *Phycopeltis microthyrioides*, described by Kirchheimer (1942 a) from the Tertiary of Lusitia (Wiese bei Kamenz). Algae of this genus have been fairly frequently found in deposits of this age but as a rule they have been described as remains of fungi from the family *Microthyriaceae*. According to K i r c h h e i m e r (l.c.), who has carried out a revision of to date determinations, in Tertiary floras there occur 2 species of the genus *Phycopeltis: Ph. Koeckii* Kirchh. from the Geiseltalian Eocene and *Ph. microthyrioides* Kirchh. from the Upper Oligocene of Lusitia [1].

The contemporary species *Ph. epiphyton* is widespread in the tropical jungle of the intertropical zone. It occurs on coniferous and broad-leaved evergreen trees whose longevity assures full development of the alga.

In Poland the fossil species *Ph. microthyrioides* was identified for the first time in the Miocene flora from Stare Gliwice (S z a f e r 1961) on the evergreen leaves of the Mediterranean shrub *Buxus sempervirens*.

FUNGI

Remains of fungi in the form of small and diversiform sclerots or globular fructifications were found in 20 samples coming from the following localities: Bodzanów, Książnice, Kłaj, Siedlec, Gierczyce and Dąbrowica.

In many samples there were also found fragments of leaves covered with black specks of various size and shape which are similar to pycnidia of some unidentifiable parasitic fungi, *Fungi Imperfecti* (cf. B a r n e t t 1962). When these pycnidia are dislodged there remains a circular or oval vestige of the thallus with a ragged margin (Pl. I, *6—8*).

In the fairly abundant fossil material it was possible to identify only the genera *Trematosphaerites* (*Ascomycetes*) and *Polyporites* (*Basidiomycetes*).

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[1] The flora from the locality of Wiese b. Kamenz is nowadays regarded as Lower or even Middle Miocene (M a i 1960, 1961).

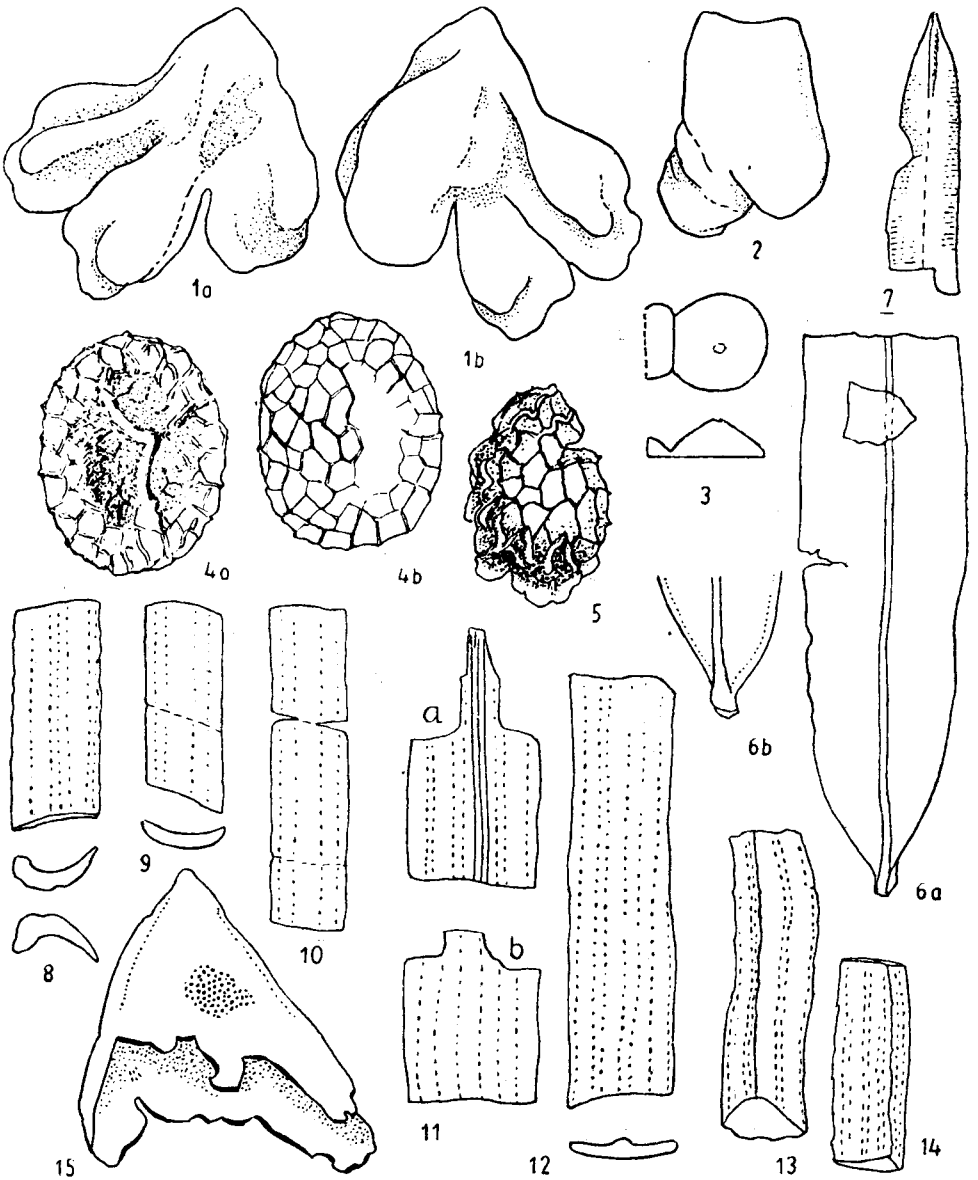


Fig. 5. *1, 2. Actinomyces Alni* Harz, × 10 (Suchoraba 21); *3.* cf. *Trematosphaerites lignitum* (Heer) Mesch., peritheciae, × 30 (Kłaj 49); *4, 5. Selaginella pliocaenica* Dorof., megaspores, × 40 (Kłaj 46, 52); *6.* cf. *Cephalotaxus* sp., × 7 (Pierzchów 30); *7.* cf. *Picea* sp., × 10 (Pierzchów 27); *8—14. Pinus* sp. div., × 10 (Pierzchów 27, *8;* Pierzchów 30, *11—14;* Kłaj 46, *9, 10*); *15. Pinus* sp., seed, × 13 (Pierzchów 30).

Ryc. 5. *1, 2. Actinomyces Alni* Harz, × 10, (Suchoraba 21); *3.* cf. *Trematosphaerites lignitum* (Heer) Mesch., otocznie, × 30 (Kłaj 49); *4, 5, Selaginella pliocaenica* Dorof., megaspory, × 40 (Kłaj 46, 52); *6.* cf. *Cephalotaxus* sp., × 7 (Pierzchów 30); *7.* cf. *Picea* sp., × 10 (Pierzchów 27); *8—14. Pinus* sp. div., × 10 (Pierzchów 27, *8;* Pierzchów 30, *11—14;* Kłaj 46, *9, 10*); *15. Pinus* sp., nasienie, × 13 (Pierzchów 30)

Amphisphaeriaceae

Trematosphaerites lignitum (Heer) Mesch.

Fig. 5, *3*

Locality: Kłaj 49

There have been preserved one complete perithecium and a small fragment of another closely adjacent. The perithecium is black, smooth, and conical in shape with an aperture in the centre; its diameter is 0·4 mm. at the base. Spores have not been preserved because the perithecium was wrenched from its base and filled up with silt.

Such fructifications occur in the genus *Trematosphaerites lignitum* (Heer) Mesch, known from Tertiary floras. They are usually groups of solitary perithecia but there also occur double specimens, confirmed in the Miocene of Wieliczka by W. Zabłocka (1931, Pl. 15, fig. 5).

This fungus is also known from other Miocene floras of Poland: Turów (Skirgiełło 1961), Domański Wierch, Jabłonka (Łańcucka-Środoniowa 1963).

Pyrenomycetes

Pl. II, *1*

Locality: Pierzchów 30

2 fragments of fungus measuring 4·5 × 3·5 mm. and 2·5 × 1·5 mm. and 1 mm. thick were found. On their upper surface there occur shallow and fairly regular cavities circular or somewhat oval in shape and nearly 0·3 mm. in diameter. The lower smooth surface is lignified. They are probably remnants of the stroma of a fungus of the *Pyrenomycetes* with cavities from fallen out peritheciae. A closer identification is not possible owing to the complete absence of peritheciae.

Polyporaceae

Polyporites sp.

Pl. II, *2*

Locality: Kłaj 35

A fragment of the hymenium was found measuring 2·0 × 1·4 mm. with a thickness of 0·3 mm. Apertures in the hymenium are irregular, about 0·2 mm. in diameter and fairly thick-walled. From side parallel running

tubules are visible. This remnant is reminiscent of the hymenium of the genus *Polyporus* but is too fragmentary to allow a closer identification.

The genus *Polyporus* occurs in the Miocene of Stare Gliwice (Szafer 1961).

MUSCI

Pl. II, *3—8*

Tiny stems and single leaves of mosses were found in 4 samples originating from Pierzchów, in 3 from Kłaj, and in 1 sample from Suchoraba. The entire material from Pierzchów and Kłaj was examined under a binocular microscope. The stem of moss found in the sample from Suchoraba was stuck to a piece of lignite. The absence of moss remains in samples from the other stations may be partly due to a less careful method of work. Altogether 14 tiny sprays and about 30 single leaves were extracted from the deposit. In the main they are poorly-preserved so that their cell structure could be investigated only with difficulty.

From this so fragmentary material Prof. B. Szafran indentified 11 various forms whose description is the subject of a separate paper (Szafran 1964). I confine myself to mentioning only some details concerning the habitats and contemporary distribution of the species found. These data I owe to the kindness of Prof. B. Szafran.

What is striking in the composition of mosses found in deposits of the „Gdów Bay" is that they are almost all forms characteristic of the contemporary deciduous and mixed forests of the temperate zone. Absent among them are tropical and subtropical species occurring in the younger flora of Stare Gliwice (Szafran 1958). Exotic genera discovered at Stare Gliwice such as *Papillaria, Trachycystis, Claopodium, Eriodon,* or *Macrothamnium* have no counterparts in the „Gdów Bay".

The only species of subtropical type is *Echinodium Savicziae.* This distinctly „cool" character of the flora of mosses of „Gdów Bay" is probably connected with its being situated in the Carpathian foreland. Plant communities which covered this foreland in the Tortonian undoubtedly had smaller climatic requirements than the Silesian Upland and Stare Gliwice, remote from the mountains. The mosses of the „Gdów Bay" were constituents of the vegetation of deciduous and mixed forests of mountainous type on the then already fairly high Carpathian ranges.

It is interesting that almost all the identified mosses from the „Gdów Bay" have been described from Pliocene deposits occurring on the river Duab in Abchasia in the foothills of the Caucasus (Abramov and Abramova 1959). In the list of 30 species of the mosses from Abchasia common to the „Gdów Bay" are the following: *Thamnium alopecurum,*

Table 8
Tabela 8

Mosses identified in the Tortonian of the „Gdów Bay".
Mchy stwierdzone w „Zatoce Gdowskiej"

Species identification Oznaczenie gatunków	Site and Sample No. Stanowisko i nr próby	Contemporary habitats Siedliska współczesne			Geographical element Element geograficzny
		Tree stems Pnie drzew	Rocks Skały	Forest type Typ lasu	
Neckera sp.	Kłaj 42, 55	+	+		
Thamnium alopecurum Br. eurp.	Kłaj 55		+	deciduous forest	subatlantic
Echinodium Savicziae A. J. Abr.	Suchoraba 24	+	+		subtropical
Anomodon longifolius Bruck.	Pierzchów 29	+	+	deciduous forest	Eurasian
Heterocladium squarrosulum Lindb.	Pierzchów 28		+	mountain forest	arctic-alpine
Brachythecium velutinum Br. eurp.	Kłaj 55	+	+	beech forest and thickets	holarctic
Brachythecium sp.	Pierzchów 31				
Cirriphyllum piliferum Grout.	Pierzchów 29			deciduous and mixed forest	holarctic
Eurhynchium pulchellum Dix.	Pierzchów 29	+		deciduous and coniferous forest	holarctic + Ecuador
Eurhynchium Swartzii Curr.	Pierzchów 28			deciduous forest and thickets	Eurasian
Eurhynchium sp.	Pierzchów 30				

Echinodium Savicziae, Anomodon longifolius, Brachythecium velutinum, Cirriphyllum piliferum and *Eurhynchium pulchellum.* The difference in age with such a composition of flora is to some extent offset by the more southern position of Abchasia in the foothills of the Caucasus.

LYCOPODINAE

Selaginellaceae

Selaginella pliocaenica Dorof.

Fig. 5, 4, 5

Locality: Kłaj 46, 52

A megaspore 0·8 × 0·6 mm. in diameter, elipsoidal in shape, considerably flattened. Of the tetraedric mark only 2 scars are visible, the third being destroyed. The megaspore has on its surface small narrow striae which form a fairly regular 4—6-gonal network clearly visible especially after the drying up of the megaspore. These striae are sometimes fairly prominent; this can be observed in the specimen coming from the Kłaj 52 sample.

Similar remains were regarded by Dorofeev (1957b, 1963a) as belonging to the species *S. pliocaenica* whose megaspores approximate most to the contemporary Northern American species of *S. apoda* (L.) Tern. and *S. densa* Rydb.

The megaspores of *S. apoda* coming from the available herbarium material are, however, considerably smaller, being about 0·5 mm. in diameter. The meshes of the network in relation to the surface of the megaspore as a whole are somewhat larger and more elongated than in the megaspores of *S. pliocaenica.* In addition, in *S. apoda* there occurs a distinctive peripheral ridge separating the area between the tetraedric mark from the rest of the megaspore. This area is covered with a much more delicate and poorly visible network, which distinguishes it from the rest of the megaspore. In the Pliocene species described by him, Dorofeev does not mention such a characteristic. Nor can regular peripheral ridges be seen at all in the specimen from Kłaj although the area of the megaspore between the three scars is almost completely devoid of reticulation.

The megaspores of *S. pliocaenica* Dorof. occur frequently in the Pliocene floras of the European part of the USSR and Western Siberia. In Poland they are known from the Pliocene of Krościenko (the sample examined in 1959 by Dorofeev) and from a number of Miocene floras of Southern Poland: Jabłonka, Domański Wierch, Morsko, Skopanie (Łańcucka-Środoniowa, 1963).

GINKGOALES

Ginkgoaceae

Ginkgo adiantoides (Ung.) Heer

Pl. II, *9, 10;* Pl. III, *1, 2*

Localities: Pierzchów 26; Kłaj 40

On a leaf fragment from Pierzchów measuring 2·0 × 1·5 mm. there can be seen 3 dark-coloured longitudinal veins running at about 0·6 mm. intervals and 3 resin receptacles fusiform in shape. They are in the form of dark-brown opaque stains 0·3 — 0·5 mm. long. That the described remains belong to the *Ginkgo* genus is beyond doubt.

The three leaf fragments of *Ginkgo* found in Kłaj have the following dimensions: 4·0 × 3·0 mm., 3·5 × 3·0 mm. and 3·0 × 2·5 mm. They are considerably fossilized as a result of which the veins and resin receptacles are not easily perceptible. Preserved epidermises of the leaves contain distinctive stomata scattered densely and asymmetrically among longitudinal veins. The circular stomata are composed of 2 polar cells and several enclosing ones from which run roller-like projections imparting to the space round the stoma opening polygonal shape (Pl. III, *1, 2*).

Small differences in the anatomical structure of leaves and especially in the structure of the stoma permit the distinction of the extinct species of *Ginkgo adiantoides* (Ung.) Heer from the contemporary *G. biloba* L. Known from many Tertiary floras of Eurasia, *G. adiantoides* was found in Poland for the first time at Stare Gliwice (W ą s 1956).

CONIFERAE

Cephalotaxaceae

cf. *Cephalotaxus* sp.

Pl. III, *4, 5; Fig.* 5, 6

Localities: Pierzchów 30, Kłaj 44

In the sample from Pierzchów the lower part of a flat needle 3 mm. wide and with a slightly twisted base has been preserved. On its lower side a vein can be seen in the middle and at the margins two non-stomata-bearing bands which are conspicuous for their smooth and shiny surface.

The specimen is strongly pyritized and the stomata are not visible under the microscope.

The relatively large breadth of the needle, the asymmetrical shape of the base, and the course of the vein, distinctly thickened in this spot, point to the *Cephalotaxus* genus (cf. M ä d l e r 1939, Abb. 3; M i k i 1958, Fig. 4/c). Unfortunately, it was not possible to corroborate this identification anatomically.

Nevertheless some confirmation is furnished by small fragments of cuticles (0·5 — 1·0 × 0·3 — 0·8 mm.) found in the sample from Kłaj. They contain stomata arranged in fairly close-set parallel rows whose number must have been considerable because on very small fragments of epidermis 7 rows of stomata were identified. Bean-like stomatal cells are brown in colour and contain a light aperture in the centre. In addition there are visible characteristic thickenings of the cuticle in the form of fork-like bifurcations and one or two polar cells. Although it was not possible to investigate satisfactorily the stomatal structure it seems, however, that the described cuticles may have originated from the needles of the genus *Cephalotaxus*.

This genus is known in Poland from the Miocene of Stare Gliwice (S z a f e r 1961) in the form of seeds of *C. Fortunei* Hook foss. and *C. Fortunei* Hook. f. *nana* Szafer and of a few fragments of needle bases. One seed of a so far unidentified species was also found in the Neogene flora of Domański Wierch (Ł a ń c u c k a - Ś r o d o n i o w a 1965).

The somewhat scanty contemporary species of the *Cephalotaxus* genus occur exclusively in South-East Asia and in the Indonesian region (Celebes, Sumatra). The species *C. Fortunei* Hook grows wild in the mountains of some provinces of Eastern and Southern China.

Pinaceae

Abies sp. div.

Fig. 6, *1—30*

Localities: Suchoraba 20, 21, 22, 23; Pierzchów 27, 30; Kłaj 39, 55, 57; Siedlec 58, 63, 64; Gierczyce 66

Fragments of fir needles abound in numerous examined samples originating from five localities. The *Abies* genus was identified on the basis of a good many well-preserved apical portions of the needles, very typical in their shape. In relation to the number of preserved remains of other plants, the share of fir is considerable and is corroborated by the findings obtained by means of pollen analysis (cf. p. 12). In the pollen spectrum from Suchoraba the share of the *Abies* genus amounts to 11 per cent.

In estimating the systematic position of the needles in question it was possible to take into account only their morphology because all of them were so corroded that the examination of details of their anatomical structure proved to be out of the question. On the basis of morphology alone, in the material from the „Gdów Bay" three main groups of needles were distinguished.

To the first group (Fig. 6, *1—7*) belong 10 needles almost uniformly narrow 1·1 × 2·1 mm. in width and with a shallow apical incision placed symmetrically or slightly asymmetrically. On the inner surface of three needles are conspicuous 2 bands of stomata which do not merge at the apex but are separated to the very end by a non-stomata-bearing band running alongside the main vein. This band is usually much broader than the lateral non-stomata-bearing bands. This type of needle occurs in the species *Abies alba* s. l., among others.

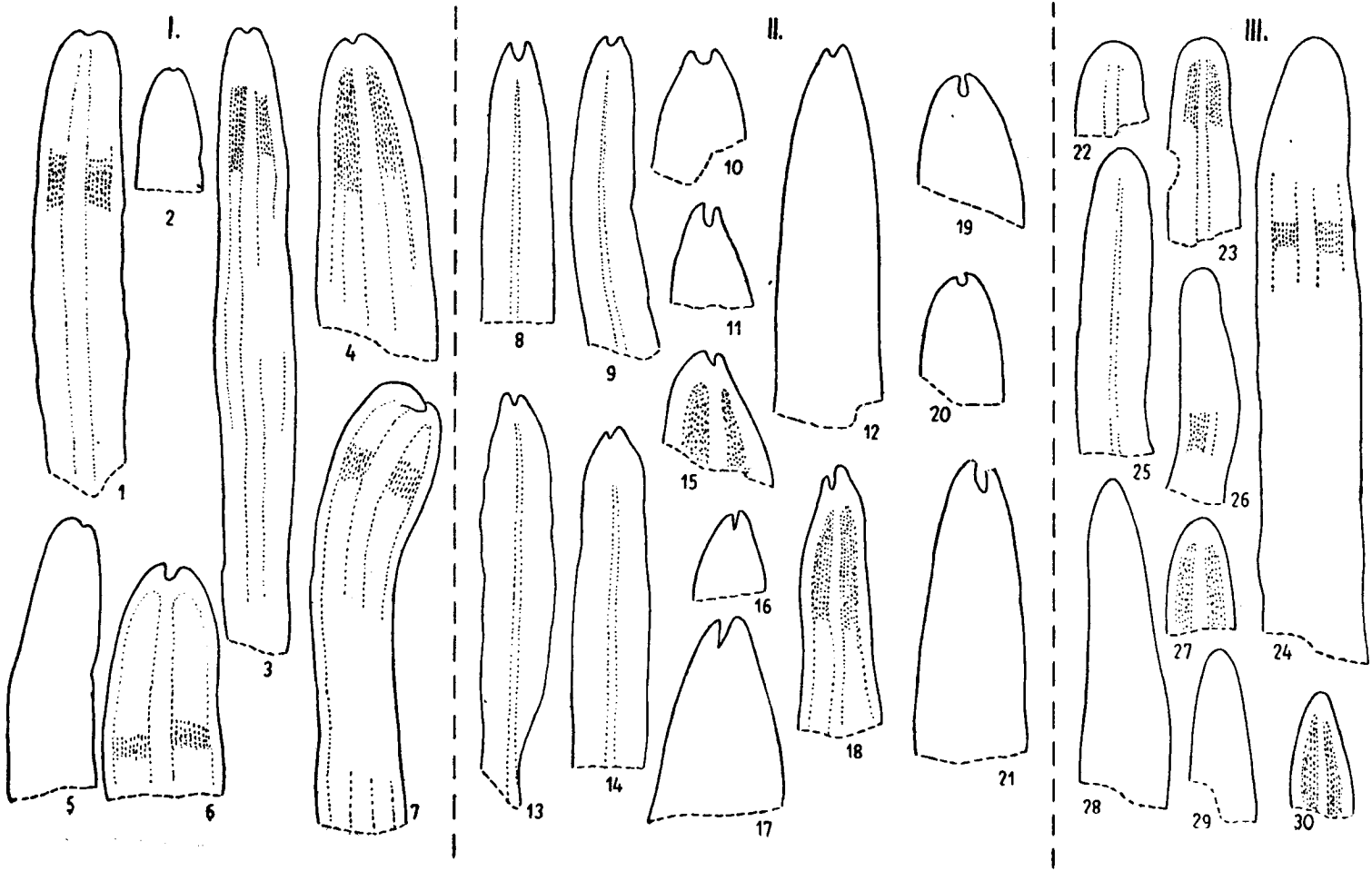
The second group (Fig. 6, *8—12, 21*) is represented by 19 needles 1·2 — 2·1 mm. broad. On the apex, narrowing cuneately, they have a fairly deep and steep incision, placed as a rule asymmetrically. In some specimens it was possible to investigate narrow vein and stomatal bands. Needles of this type occur relatively the most frequently in the examined flora and they approximate, as far as the shape of their apices is concerned, many East-Asiatic species of firs such as, for instance, *A. homolepis* S. et Z., *A. nephrolepis* Max., *A. firma* S. et Z., *A. chensiensis* Van Tiegh, *A. sutchensis* Rehd. et Wils., or *A. Faxoniana* Rehd. et Wils.

To this group have also been assigned two needles originating from the Siedlec 63 sample (Fig. 6, *19, 20*) which on rounded apices have deep incisions and the margins of blades inflected hook-like towards the centre. This type of structure is sometimes displayed by the needles of some of the East-Asiatic species previously referred to, for instance *A. nephrolepis* Max. and *A. homolepis* S. et Z.

It should be stressed that the depth of the apical incision, the symmetry, or the smaller or greater asymmetry of the two margins of blades are very variable features in individual species of firs. For this reason, specific determination without the possibility of a close examination of the anatomical structure of the needles would not be justified.

To the third group belong 14 needles lacking an incision at the apex which is rounded or cuneately elongated (Fig. 6, *22—30*). The needles are completely flat with a well-defined, in some specimens, central vein and lateral non-stomata-bearing bands. That they belong to the genus *Abies* is in principle beyond doubt but nevertheless specific determination is not possible because needles of this type of morphological structure occur in various species of firs, among others, they are occasionally encountered also in *Abies alba.*

The distinction of as many as three types of fir needles in such a poorly and fragmentarily preserved fossil material is a proof not only of consider-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able taxonomic differentiation within the scope of this genus but also of the importance of its role in the composition of the then existant plant communities. This is further corroborated by the abundance of fir needles in the Miocene of Stare Gliwice in which W. S z a f e r (1961) discriminated 6 species: *Abies alba* Mill. s. l. foss., *A.* aff. *homolepis* S. et Z., *A.* aff. *nephrolepis* Max., *A.* aff. *koreana* Wils., *A. sclereidea* Mädl., *A.* sp. 1. In the needle material of the genus *Abies* from Gliwice and the „Gdów Bay" the strong connection with contemporary East-Asiatic species is striking.

Occurrences of the genus *Abies* in the Miocene of Southern Poland: Stare Gliwice, the "Gdów Bay", Niepołomice, Morsko, Skopanie, Chyżne, Domański Wierch.

cf. ***Picea*** sp.

Fig. 5, 7

Locality: Pierzchów 27

A narrow needle, about 1 mm. in width, symmetrical, sharp-pointed. It was not completely flat because near the apex it exhibits a convex fold running downwards through the middle of the needle. From the smooth margins of the needle towards its centre there run horizontal, minute, and parallel striae perpendicular to the longitudinal axis of the needle. The fragment described above displays in its morphological structure characteristics of the needles of the genus *Picea* although it is possible to detect also a certain similarity to the needles of the genus *Taxodium* (cf. Fig. 7, 2) which are flatter, however.

Maceration of this needle revealed the presence of stomata arranged in lines running parallel to the vein and of strongly undulate membranes in epidermal cells. These anatomical features preclude the ascribing of the described fragment to the genus *Taxodium* in which the stomata are aligned more or less perpendicularly to the course of the vein and the epidermal cells have smooth membranes. It was not possible to trace the stomatal structure, hence identification is uncertain.

Fig. 6. *1—30. Abies* sp. div., apical parts of needles, × 10 (Suchoraba 20, *12;* Suchoraba 21, *8, 14;* Suchoraba 22, *1, 3, 9, 13;* Suchoraba 23, *16;* Pierzchów 27, *17;* Pierzchów 30, *2, 5, 6, 7, 11, 15, 18, 23—26, 30;* Kłaj 55, *4, 22, 27, 29;* Siedlec 58, *10, 28;* Siedlec 63, *19—21*).

Ryc. 6. *1—30. Abies* sp. div., części szczytowe szpilek, × 10 (Suchoraba 20, *12;* Suchoraba 21, *8, 14;* Suchoraba 22, *1, 3, 9, 13;* Suchoraba 23, *16;* Pierzchów 27, *17;* Pierzchów 30, *2, 5, 6, 7, 11, 15, 18, 23—26, 30;* Kłaj 55, *4, 22, 27, 29;* Siedlec 58, *10, 28;* Siedlec 63, *19—21*)

The share of the genus *Picea* in the pollen spectrum from Suchoraba amounts to 12 per cent.

Occurrences of the genus *Picea* in the Miocene of Southern Poland: Stare Gliwice, the "Gdów Bay", Niepołomice (?), Posądza (?), Chyżne, Domański Wierch.

Pinus sp. div.

Pl. IV, *1—4;* Fig. 5, *8—15*

Localities: Pierzchów 27, 30; Kłaj 39, 46, 49

In a few samples about 60 fragments were found of needles of the genus *Pinus* and one short shoot with the bases of 2 needles. The needles are 1—2 mm. wide and not more than 1 cm. long.

Some specimens, slightly convex on one side and concave on the other, have no well-defined central vein. In cross-section these needles are of a typical crescent shape (Fig. 5, *8—10*). Their margins are uneven, sometimes serrated and both surfaces are covered with parallel running rows of stomata. Needles of a similar structure occur also in the section of two-needle pines.

Also numerous are strongly flattened needles with a conspicuous central vein on one side (Fig. 5, *11, 12*). On both sides occur parallel rows of stomata arranged and constructed in the manner characteristic for the genus *Pinus*, this being congirmed by anatomical examination of the epidermis. Needles of this type occur in three-needle pines (the section *Taeda*).

In addition, sample 30 from Pierzchów contained a few specimens of needles markedly triangular in shape (Fig. 5, *13, 14*) with distinctly serrated margins. On all three sides there are parallel rows of stomata. Anatomical examination of the epidermis revealed the structure characteristic for the genus *Pinus* (Pl. IV, *1—3*).

From the same sample originates one seed with a destroyed basal part. It was 3 mm. wide and probably about 6 mm. long. The seed is strongly flattened with a markedly elongated apical portion sides covered with sharp, narrow edges. From this it may be inferred that it was not blunt in shape but slightly vaulted lengthwise. As the relatively thick shell is broken off, the interior wall of the seed, with its perfectly smooth surface, is exposed. Exterior walls display regular minute pitting. The described seed can be ascribed to the genus *Pinus*. Apart from shape and size, this is supported by the presence of lateral longitudinal ridges and by the pitted sculpture of the surface. These last two features, as well as the absence of the longitudinal chalazal depression at the apex, exclude the possibility

of ascribing the described fragment to the genus *Pirus* or *Malus* in spite of a quite considerable resemblance as regards shape.

Easily identifiable seeds of the genus *Pinus* come mainly from leafy floras where they had the chance of being preserved together with wings. The seeds without wings are more difficult to determine and can be mistaken for altogether different genera (Kirchheimer 1957). Nevertheless, specific determination is in some cases possible (Miki 1938, 1948, 1957; Mai 1960; Kokawa 1961).

The considerable share of macroscopic remains of the genus *Pinus* in the flora of the „Gdów Bay" tallies with the findings of the pollen analysis (cf. p. 12) which disclosed that in amounted to 63 per cent. These results are also in accord with the known fact that on the territory of Southern Poland there grew in the Tortonian many species of pines possessing today related counterparts in the regions of North America, East Asia, and Europe.

Occurrences of the genus *Pinus* in the Miocene of Southern Poland: Dierżysław, Zbrosławice, Kokoszyce, Stare Gliwice, Wieliczka, Łagiewniki, Wola Duchacka, Bonarka, the "Gdów Bay", Zakrzów, Niepołomice, Niskowa, Domański Wierch.

Taxodiaceae

Taxodium distichum miocaenicum Heer

Pl. III, *3*; Fig. 7, *1—6*

Localities: Pierzchów 29, 30; Książnice 32

6 needles were found, very thin and tender, about 1 mm. in width. Through the middle of the needles, sharply drawn out at the apex, there run delicate veins. Under the microscope can be seen in some specimens, on both sides of the vein, rows of stomata which are arranged horizontally, i.e. at right angles to the path of the vein. The margins of the needles are markedly thin.

As regards morphological structure, these remains correspond well to needles of the genus *Taxodium*. During maceration it was impossible to obtain the picture of the stomata, one could only establish that epidermal cells were not too elongated and had smooth walls.

To the genus *Taxodium* probably also belongs a fragment of epidermis measuring 1·2 × 0·9 mm. contained in the Pierzchów 29 sample. In this fragment are noticeable parallel running elongated cells of the central vein, which have smooth walls and by their side stomata arranged perpendicularly or obliquely in the manner characteristic of the genus *Taxodium* (Florin 1931; Miki 1953).

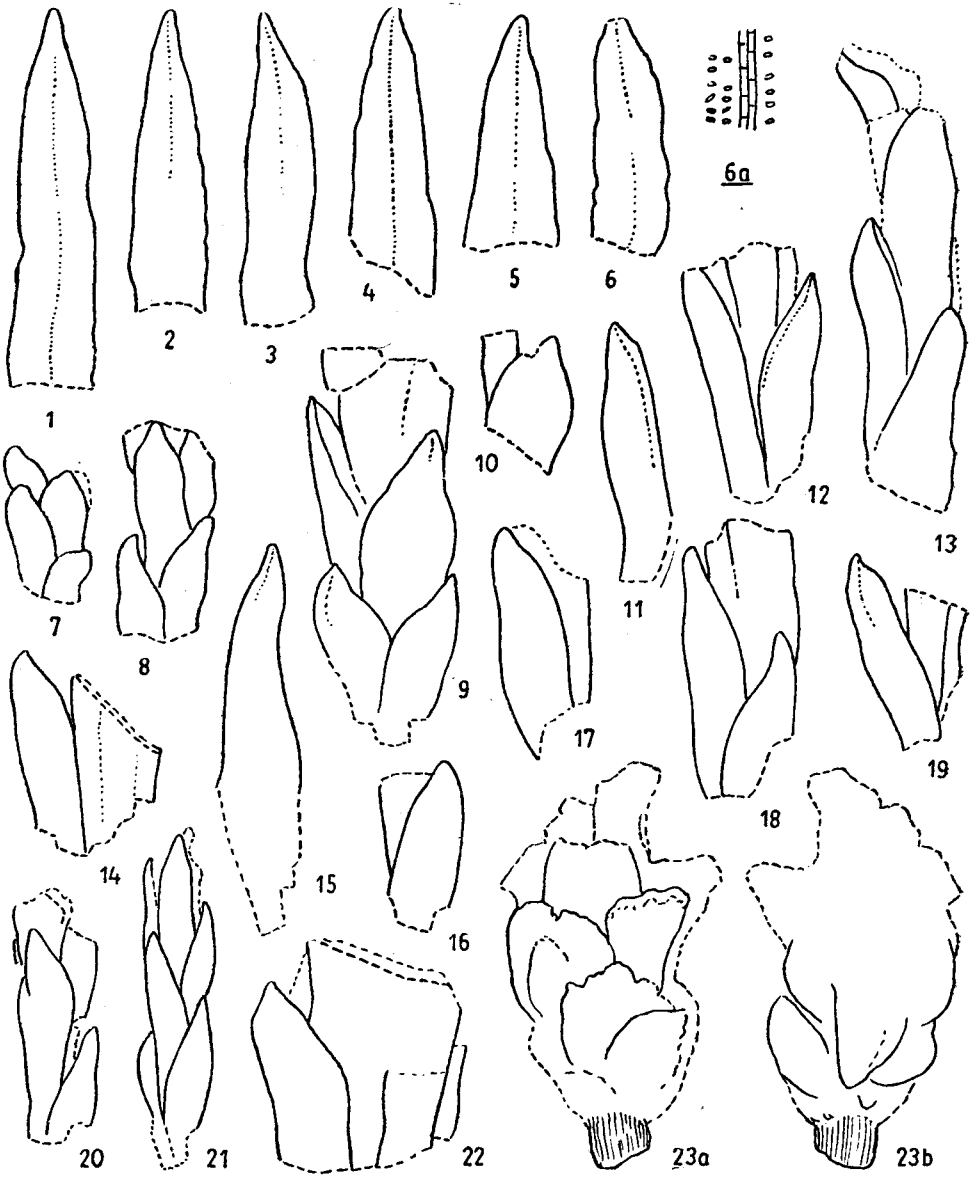

Fig. 7. *1—6. Taxodium distichum miocaenicum* Heer, × 10 (Pierzchów 30, *1, 6;* Książnice 32, *2—5*); *7—22. Glyptostrobus europaeus* Heer, fragments of twigs and leaves, × 10 (Sypka Góra 13, *16, 18;* Liplas 15, *9, 12, 13, 17, 20, 21;* Suchoraba 21, *15;* Suchoraba 24, *7, 8;* Pierzchów 30, *22;* Książnice 32, *11, 19;* Kłaj 55, *10, 14*); *23. Glyptostrobus europaeus* Heer, basal part of cone, × 6 (Suchoraba 24).

Ryc. 7. *1—6. Taxodium distichum miocaenicum* Heer, × 10 (Pierzchów 30, *1, 6;* Książnice 32, *2—5*); *7—22. Glyptostrobus europaeus* Heer, fragmenty gałązek i listków, × 10 (Sypka Góra 13, *16, 18;* Liplas 15, *9, 12, 13, 17, 20, 21;* Suchoraba 21, *15;* Suchoraba 24, *7, 8;* Pierzchów 30, *22;* Książnice 32, *11, 19;* Kłaj 55, *10, 14*); *23. Glyptostrobus europaeus* Heer, nasadowa część szyszki, × 6 (Suchoraba 24)

The species *Taxodium distichum miocaenicum* Heer, known from numerous Tertiary flora of Eurasia, has recently been reported under the name of *T. dubium* (Sternb.) Heer (Dorofeev 1963a; Mai 1963; Knobloch 1963; Kosman 1964).

Occurrences in the Miocene of Southern Poland: Stare Gliwice, Swoszowice, Wieliczka, the "Gdów Bay", Chyżne (?).

Glyptostrobus europaeus Heer

Fig. 7, 7—23

Localities: Sypka Góra 13; Liplas 15; Suchoraba 21, 24; Pierzchów 30; Książnice 32; Kłaj 55

Fragments of twigs of *Glyptostrobus europaeus* Heer were found in 7 samples from 6 different stations scattered over the entire territory of the „Gdów Bay". The obtained fossil material consists of 15 tiny leafy twigs, 1—3 mm. wide and 2—6 mm. long, and of 9 single leaves. The leaves are more or less elongated, scaly, characteristically converging along the shoot.

It may be open to doubt whether it was right to determine specimens with leaves bent in somewhat sicle-like towards the centre (Fig. 7, *20, 21*) because the leaves of *Sequoia Cousttsiae* Heer may also be of similar shape. There is little likelihood of this, however, for the latter are, in their lower part, conspicuously narrowed (Zalewska 1959, Fig. 4a). Moreover, it was found that leaves of similar shape occur in the genus *Glyptostrobus* on the tips of young twigs (herbarium material brought from China by Dr. A. Jasiewicz in 1959).

In sample 24 from Suchoraba there was found also a thicker twig characteristically wrinkled on the surface, with traces of very short leaves as well as a cone fragment 9 mm. high and 5 mm. wide. The cone is strongly flattened and abraded, nevertheless its base is visible as are outlines of a few scales on each side. At the base of the cone, the scales are short and broad, somewhat sharply drawn out at the apex. Young and poor-developed cones of the genus *Glyptostrobus* have scales of this type not only in the basal but also in the central part. In the upper margin of one scale typical indentations have been preserved.

Occurrences of the genus *Glyptostrobus* in the Miocene of Southern Poland: Stare Gliwice, Opatowice, Wieliczka, the "Gdów Bay", Kąty, Bielawice, Grudna Dolna, Ujście, Leszek, Chyżne.

Cupressaceae

Thuja cf. *occidentalis* L.

Pl. IV, *5, 6;* Fig. 8, *1—4*

Localities: Pierzchów 27; Kłaj 46, 53

Four fragments of leafy twigs have tiny scaly leaves mounted in nodes [1]. Individual parts of the shoot are more than 2 mm. high and 1·9 — 2·6 mm. wide with maximum width at half the height or somewhat above it. Hooked marginal leaves are contiguous at the base only. In the lower portion of these leaves are surfaces (s) overlapped by the apex of the preceding part of the shoot. Flat facial leaves have elongated apices from which a marked thickening runs downwards through the centre of the leaf. The twigs are dorsally ventral which is noticeable in the 2 larger specimens (Fig. 8, *1, 4*). On one side the leaves are smooth and on the other their surfaces show pits, probably after stomata.

The remains described above correspond best to the twigs of the North American species *Thuja occidentalis* L. It was impossible, however, to trace the shape of resin receptacles (an important diagnostic) or to carry out anatomical examination of the epidermis. Remains of similar structure have been described from the Pliocene of Japan as *T. protojaponica* Miki (M i k i 1941, 1958) and from the Miocene of Tuscany as *T. saviana* Gaudin (cf. Berger 1957). The species *T.* cf. *occidentalis* has been reported from the Pliocene of Georgia (K o l a k o v s k i j 1954) and the Miocene flora of Turów (Z a l e w s k a 1962) [2].

Both the North American and East Asiatic species of the genus *Thuja* are remarkable for their requirements as regards air and soil humidity. Thus, for instance, *T. occidentalis* L. grows in the eastern part of North America on low-lying wet ground where it forms separate woods or parts of mixed forests. The majority of species of this genus may occur also in the mountains at considerable altitudes.

It should be stressed that for some time attention was drawn to the considerable morphological similarity of leafy twigs of the genera *Thuja, Thujopsis,* and *Biota* (cf. C z e c z o t t 1961, p. 125). According to F l o r i n, fossil remains of *Thuja* type are very difficult or, sometimes, altogether impossible to determinate for a number of related genera (*Thuja, Phyllocladus* = *Biota, Thujopsis, Calocedrus* and *Microbiota*) have a very similar

[1] The specimen from the Pierzchów 27 sample (Fig. 8, *2*) was formerly mistakenly ascribed to *Heyderia (Libocedrus)* aff. *decurrens* (Ł a ń c u c k a - Ś r o d o n i o w a 1963).

[2] Considerable similarity to this species is shown by the twigs of *Thuja occidentalis succinea* Goepp. preserved in amber (Z a l e w s k a 1964).

shoot structure. R. F l o r i n in presenting the distribution of occurrence of fossil *Coniferae*, joins remains similar to *Thuja* under the common name of *Thujopsideae*. Plants of this type are known in Europe from Palaeogene to Pliocene (F l o r i n 1963, Fig. 41).

In spite of these undoubtedly well-founded reservations of R. F l o r i n, I ascribe the remains from the „Gdów Bay" to *Thuja* in view of their substantial morphological similarity to species of this genus.

Occurrences of the genus *Thuja* in the Miocene of Southern Poland: Wieliczka, the "Gdów Bay", Chyżne.

Hellia salicornioides Ung.

Fig. 8, 5—12

Localities: Suchoraba 21; Pierzchów 27; Książnice 32; Kłaj 51, 53, 57; Siedlec 58, 63

9 flat shoot parts, elliptical-oval in shape, 1·7 — 3·5 mm. long and 1·4 — 2·0 mm. broad were found. The parts are mainly single, only one of them being double (Fig. 8, *11*). All specimens are rather small and probably come from subapical parts of the shoot. Marginal and facial leaves are to be seen only at the top while along the remaining length they are merged. On their surfaces occur small protuberances arranged in dense, parallel bands.

Remains possessing such typical structure and frequently found in Miocene floras of Europe have, since 1855, been described under the name of *Libocedrus salicornioides* (Ung.) Heer. The view of some authors who perceived a similarity between the extinct species *L. salicornioides* and the contemporary *L. chilensis* (D. Don) Endl. = *Austrocedrus chilensis* (D. Don) Florin et Boutelje, was not correct. Shoot parts of the latter species are distinguished, among other details, by very well-defined marginal leaves (F l o r i n, B o u t e l j e, 1954). It is also incorrect to compare these remains with the Californian species *L. decurrens* Torr. or the East Asiatic *L. macrolepis* Benth. et Hook. (cf. R a n i e c k a - B o b r o w s k a 1962, p. 97) because these two species have very well-defined separate marginal leaves.

According to M a i (1963), the remains ascribed to *Libocedrus salicornioides* belong neither to the genus *Libocedrus* nor to the genus *Heyderia* because they have different morphological and anatomical structures. Probably it is a different genus, now extinct, which as early as 1840 was ascribed by Unger to *Hellia salicornioides*.

Occurrences in the Miocene of Southern Poland: Kokoszyce, Stare Gliwice, Wieliczka, the "Gdów Bay", Skopanie.

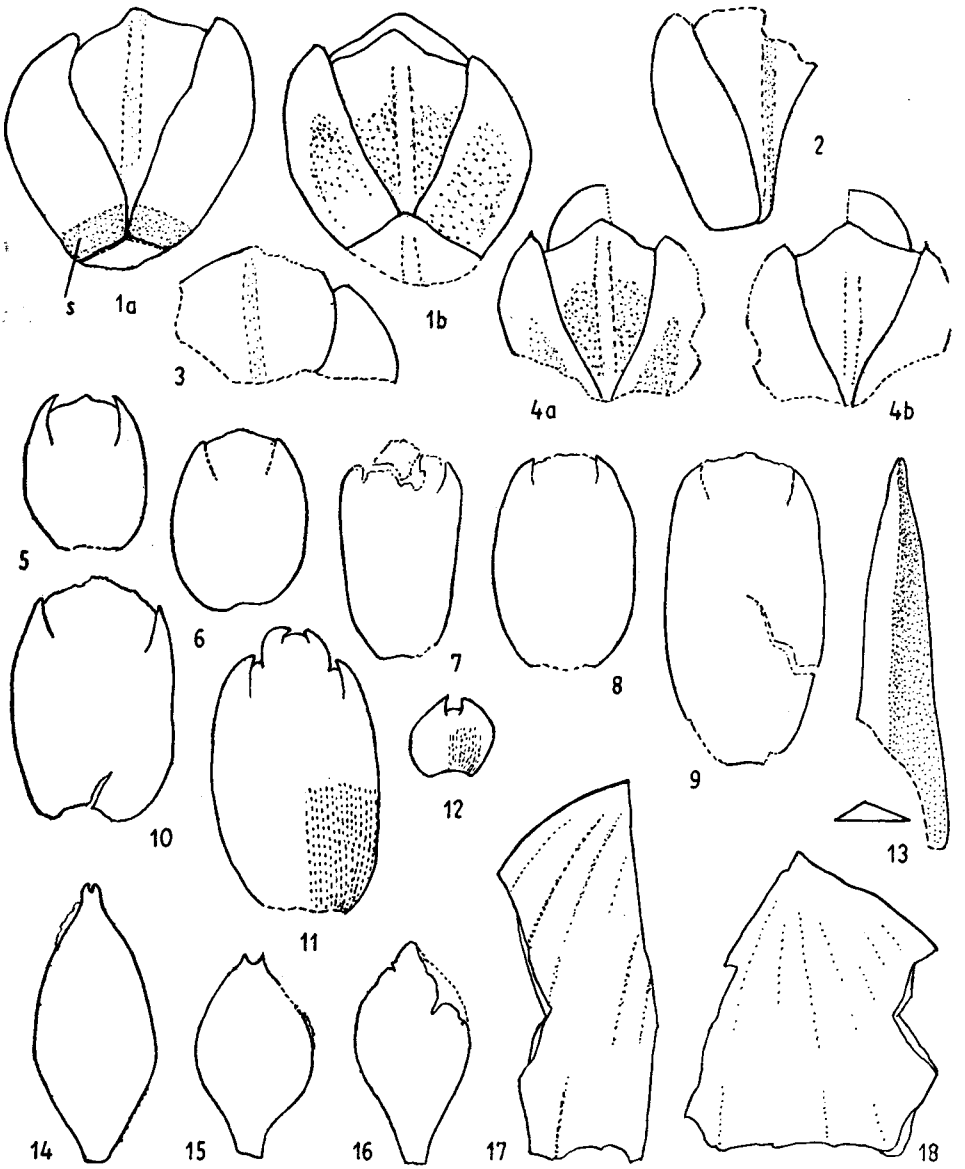

Fig. 8. *1—4. Thuja* cf. *occidentalis* L., individual parts of shoot, × 15 (Pierzchów 27, *1, 2;* Kłaj 46, *3;* Kłaj 53, *4); 5—12. Hellia salicornioides* Ung., individual parts of shoot, × 12 (Suchoraba 21, *11;* Pierzchów 77, *5;* Książnice 32, *6, 10;* Kłaj 51, *12;* Kłaj 57, *8;* Siedlec 58, *9;* Siedlec 63, 7); *13. Juniperus* sp., × 15 (Kłaj 46); *14—16. Betula* sect. *Albae* t. *pubescentes,* fruits × 15 (Książnice 32, Pierzchów 26, Siedlec 64); *17, 18. Corylus* sp., fragments of nutshell, × 8 (Siedlec 64).

Ryc. 8. *1—4. Thuja* cf. *occidentalis* L., poszczególne człony pędu, × 15 (Pierzchów 27, *1, 2;* Kłaj 46, *3;* Kłaj 53, *4);* 5—12. *Hellia salicornioides* Ung., poszczególne człony pędu, × 12 (Suchoraba 21, *11;* Pierzchów 77, *5;* Książnice 32, *6, 10;* Kłaj 51, *12;* Kłaj 57, *8;* Siedlec 58, *9;* Siedlec 63, 7); *13. Juniperus* sp., × 15 (Kłaj 46); *14—16. Betula* sect. *Albae* typ *pubescentes,* orzeszki, × 15 (Książnice 32, Pierzchów 26, Siedlec 64); *17, 18. Corylus* sp., ułamki łupiny orzecha, × 8 (Siedlec 64)

Juniperus sp.

Fig. 8, *13*

Locality: Kłaj 46

Only an apical part (3·5 × 0·8 mm.) of a needle, very narrow and tapering off to a pointed tip, has been preserved. This needle has one surface concave and the other markedly convex with domed ridge. Such characteristically constructed needles of various size and shape are peculiar to species of the genus *Juniperus*.

Needles with a similar morphological structure occur in a few East Asiatic species, for instance, in *J. chinensis* L., *J. procumbens* (Endl.) S. et Z., *J. rigida* S. et Z.

Occurrences of the genus *Juniperus* in the Miocene of Southern Poland: Stare Gliwice, Wieliczka, the "Gdów Bay", Morsko, Chyżne (?), Domański Wierch.

DICOTYLEDONES

Betulaceae

Betula sp. (sect. *Albae*)

Fig. 8, *14—16*

Localities: Pierzchów 26; Książnice 32; Siedlec 64

Three small fruits corresponding as regards shape to the genus *Betula* were found. The first specimen, coming from Książnice, is 2·2 mm. long and 1 mm. wide with the maximum width situated below the half-length mark. The fruit is narrow-elliptical, pointed at both ends. At the top a narrow trace of a wing is preserved on one side. The second specimen, from Pierzchów, is smaller (1·7 mm. × 1 mm.) and comparatively broader, elliptical-ovoid in shape, at top less markedly elongated. From the side a remnant of wing is visible. The third specimen from the site at Siedlec (2·0 mm. × 1·0 mm.) is considerably damaged in the upper part; also no wing traces are visible.

Specific determination on the basis of these three poorly preserved fragments is very difficult. At my request, Dr. M. Białobrzeska examined them employing the J. Jentys-Szaferowa's graphical method of comparing the shapes of plants (1959). The following characters were taken into account: length of fruit, breadth of fruit, ratio of length to breadth, position of the broadest part as percentage of length, apical

angle, and basal angle. Fossil fruits were compared with contemporary species such as *Betula verrucosa, B. pubescens, B. carpatica,* and *B. tortuosa* and with the fossil species *B. longisquamosa.* It should be stressed that the line of shape of each of the species referred to above was previously defined on the basis of measurements of 100 fruits while out of fossil remains only two could be used for determination. Nevertheless, as a result of this detailed biometric analysis it is possible to state that the fruits from the „Gdów Bay" belong to the section *albae* and approximate the type *pubescentes.*

Leaves of *Betula subpubescens* Goepp. have been recorded from the Miocene floras of Silesia, i.e. from Sośnica (Goeppert 1855) and from Stare Gliwice (Szafer 1961) where in addition there occur leaves of *B. macrophylla* (Goepp.) Heer and a great number of fruits of *B. longisquamosa* Mädler. Fruits of *Betula* sect. *Albae* have been discovered by Dorofeev (1963a) in the Oligocene and Miocene floras of Western Siberia.

Carpinus cf. ***betulus*** L.

Fig. 10, *1—4*

Localities: Suchoraba 21, 22; Gierczyce 66; Łapczyca 70

Altogether 5 flattened, very thin and badly damaged fruits were found. Traces of characteristic ribbing are, however, clearly visible. Two specimens from Suchoraba 22 measuring 6·0 × 4·4 mm. and 5·1 × 3·9 mm. have the shape typical of this species with a broad and slightly rounded base and somewhat bluntly elongated apex (Fig. 10, *2, 3*). The specimen coming from the neighbouring sample of the same profile has a more elongated apex, is distinguished by a great number of ribs (Fig. 10, *1*), and is comparatively large (6·5 × 4·0 mm.). The fourth specimen, very large, coming from the locality of Gierczyce 66, was unfortunately lost and cannot be described. Finally, the fifth specimen from the locality of Łapczyca 70, the most damaged and with a broken off apex, has a relatively narrow base and markedly elongated apical part (Fig. 10, *4*). The fruit is 2·8 mm. wide and it was probably a little over 5 mm. long. This specimen has a somewhat different shape from the others which can only in part be attributed to lateral crushing. It must have been more elongated and pointed at the apex and its shape similar to that of the genus *Ostrya* (*O. japonica* Sargent). These forms of fruits of the genus *Carpinus* occur comparatively frequently in Miocene deposits of Poland (Jentys-Szaferowa 1960). Because numerous fruit involucres found in these deposits are exclusively of the type *C. betulus* L. (Jentys-Szaferowa 1958), and also because leaves reported from Tertiary floras under the name of *C. grandis* Ung.

do not differ at all from those of *C. betulus* L. it might be assumed with a considerable degree of probability that the latter species grew in Poland from the Miocene. Anatomical investigations of the structure of fossil fruits of *Carpinus* in Poland have confirmed this assumption (J e n t y s - S z a f e r o w a 1961).

Occurrences of *Carpinus betulus* L. in the Miocene of Southern Poland: Czernica, Kokoszyce, Stare Gliwice, Swoszowice, Wieliczka[1], the "Gdów Bay", Chyżne, Domański Wierch.

Corylus sp.

Fig. 8, *17*, *18*; Fig. 9, *2*—*5*

Locality: Siedlec 64

Two fairly large fruit-shell fragments (6·0 × 2·5 mm and 5·0 × 4·0 mm.) probably come from the apical part of the fruit because their outer surface shows concave furrows converging in the apical part. Apart from these, also 9 smaller shell fragments with a morphological structure corresponding to the genus *Corylus* were found.

This is supported not only by the longitudinal ribbing of the outer surface of the fruit-shell and its considerable thickness (about 0·8 mm.) but, above all, by the presence of longitudinal canals in places where formerly the leading tissue was found. These canals, empty in ripe contemporary fruits, were filled in fossil specimens with a mineral substance and in cross-section appear as large brown spots. They are relatively larger and more densely arranged than in *Corylus avellana* (cf. Fig. 9, *1*).

The determination was confirmed by particulars of anatomical structure. In cross-section it is possible to trace sclerenchyma cells, very thick-walled and supplied with small transverse canals. These cells vary in shape from isodiametrical to markedly elongated according to what part of the fruit-shell they derive from (K a n i e w s k i 1964).

From the Miocene of Stare Gliwice W. S z a f e r (1961) has described several fruits of *Corylus avellana* L. s. l. foss. which have abraded and rather thin shells with longitudinal canals considerably smaller in diameter than the specimen from Siedlec. So far the genus *Corylus* has not been found at Wieliczka, though palynological analysis of Tortonian deposits from Kłaj has shown the presence of pollen grains of *Corylus* in a quantity up to 4 per cent (K i t a 1963).

Fossil material from Siedlec is too fragmentary to form a basis for specific determination. It is also not known how far the size of the dia-

[1] According to J. J e n t y s - S z a f e r o w a (1961), in the Miocene of Wieliczka, apart from fruits of *Carpinus polonica* Zabł., a species related to *C. orientalis* Mill., there occur also fruits of the type *C. betulus* L.

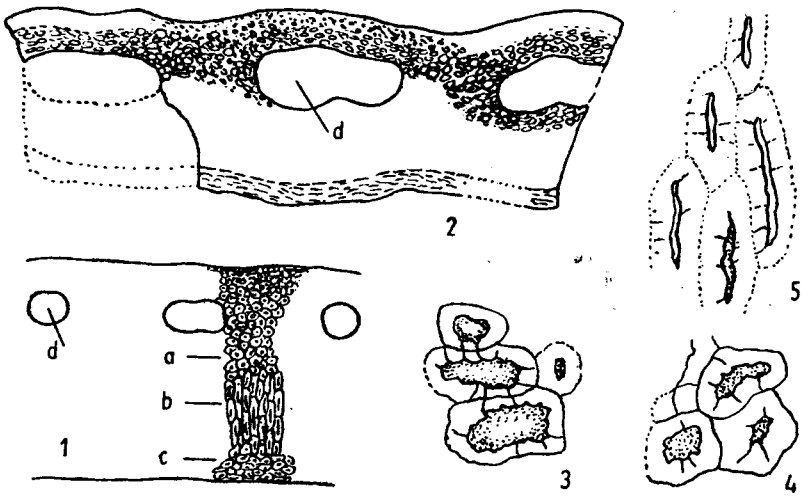

Fig. 9. Anatomical structure of nutshell of the genus *Corylus*. *1. Corylus avellana* L.: a — isodiametrical sclerenchyma cells, b — longitudinal sclerenchyma cells, c — irregularly shaped sclerenchyma cells; *2—5. Corylus* sp. (Siedlec 64): *2.* Cross-section of shell, × 30; *3—5.* Sclerenchyma cells of various types, × 580 and 1000.

Ryc. 9. Budowa anatomiczna łupiny orzecha rodzaju *Corylus*. *1. Corylus avellana* L.: a — komórki sklerenchymatyczne izodiametryczne, b — komórki sklerenchymatyczne podłużne, c — komórki sklerenchymatyczne nieregularnego kształtu; *2—5. Corylus* sp. (Siedlec 64): *2* — przekrój poprzeczny łupiny, × 30; *3—5.* Komórki sklerenchymatyczne różnego typu, × 580 i 1000

meter of longitudinal canals may have diagnostic significance in the differentiation of species.

From the Pliocene deposits at Krościenko and Mizerna W. Szafer (1946, 1954) distinguished 3 species: *C.* cf. *avellana* L., *C.* cf. *maxima* Mill. (the Crimean Peninsula, the Caucasus, Asia Minor), and *C.* cf. *rostrata* Ait. (North America). From the studies of Dorofeev (1963a) it follows that on the territory of Western Siberia there occurred in the Miocene two forms resembling East Asiatic species.

Fagaceae

Fagus sp. (aff. *orientalis* Lipsky)

Fig. 10, 5—7

Locality: Suchoraba 20, 22

Two parts of cups were found, width 7·0 mm. and length about 9·0 mm., and one damaged fruit of which only one of the three walls, 7·0 mm. wide by 4·0 mm. long, is well preserved. The characteristic shape

and 3 creases on the surface running from the apex to the base allow the determination of this fruit as belonging to the genus *Fagus*. Specific determination is not easy as fruit cups are much damaged. Probably they were large, uniformly elongate, and in the upper part broad and rounded. Excrescences on the surface had bases which converged slightly and were not regularly located.

The fruits of the genus *Fagus*, frequently encountered in the Neogene floras of Europe, have usually been compared with the North American species *Fagus ferruginea* Ait. (= *F. grandifolia* Ehrh. = *F. americana* Sveet) and with the extinct species *F. decurrens* Reid, which displays features intermediate between *F. ferruginea* Ait. and *F. silvatica* L.

W. Szafer (1961), reporting these beeches from the Miocene of Stare Gliwice, noted that „the cups of the fossil *F. ferruginea* bear resemblance not only to the North American *F. ferruginea* Ait. (= *F. grandifolia* Ehrh.) but also to the East Asiatic *F. japonica* Max."

The history of the genus *Fagus* in the Tertiary has been studied by many scientists (cf. Szafer, l. c.; Kolakovskij 1960; Palamarev 1963). A comprehensive list of the Tertiary occurrences of leaves of the beech, described under various specific names, has recently been compiled by Tralau (1962) who divided the whole material into two basic groups. To the first he assigned the leaves of the species *F. grandifolia* Ehrh. (= *F. ferruginea* Ait.) and to the second the leaves of the species *F. silvatica* L. to which belong also specimens described under the name *F.* cf. *orientalis* Lipsky. Leaves of this latter species, which grows today in Asia Minor, the Caucasus, the Crimean Peninsula, and in the Balkans, have for a long time been recorded from the Neogene floras of Bulgaria, Hungary, Italy and the USSR (cf. Tralau 1962).

Some interesting details about the history of *F. orientalis* have been furnished by the investigation of the Miocene flora from Swoszowice (Iljinskaja 1962) and the neighbourhood of Lwów (Švarjeva 1964). The leaves of *F. hertae* (Ung.) Iljin. reported from these floras are very similar to those of *F. orientalis* Lipsky. To the same species belong also, according to Švarjeva, (l. c.p. 531) specimens of leaves from Sośnica, Kokoszyce, and Stare Gliwice as well as those from various stations in Germany, Holland, southern France, and northern Italy. It would appear from this that the species of beech related to *F. orientalis* Lipsky was in the Tertiary widely distributed throughout Eurasia.

The fruits of the species *F. orientalis* have not so far been reported in the fossil state [1]. The fruits of *E. orientalis*, *F. silvatica*, and *F. grandifolia*, i.e. of the species whose leaves were examined by Švarjeva in 1964, show relatively great morphological differences which can also be of help

[1] They have recently been described from the Pliocene of Georgia by A. Kolakovskij (1964, Tabl. 26, fig. 7).

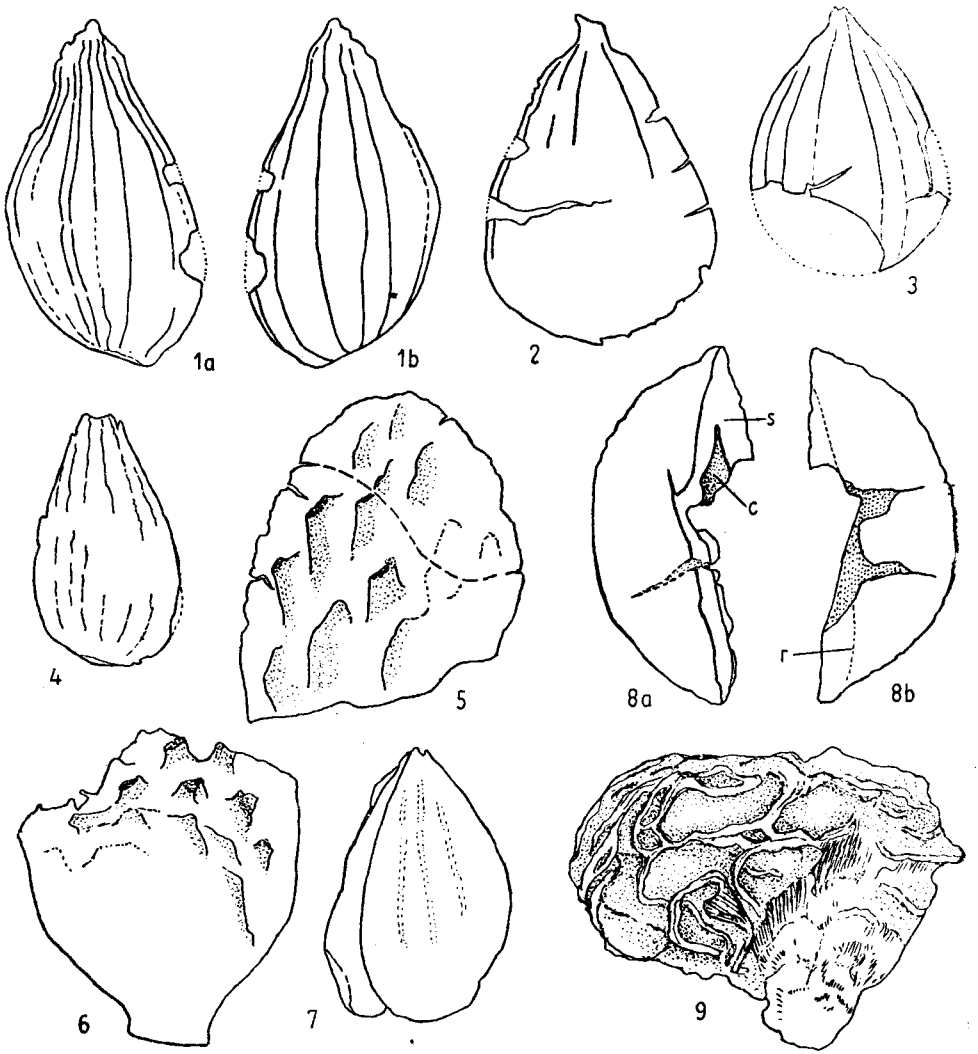

Fig. 10. *1—4. Carpinus* cf. *betulus* L., × 8 (Suchoraba 21, *1;* Suchoraba 22, *2, 3;* Łapczyca 70, *4*); *5—7. Fagus* aff. *orientalis* Lipsky, × 6 (Suchoraba 20, *7;* Suchoraba 22, *5, 6); 8. Carya* sp., half of nut, × 5: s — shell, c — ventricle, r — longitudinal ridge (Liplas 16); *9. Liquidambar* aff. *orientalis* Miller., fragment of fruiting head, × 12 (Suchoraba 24).

Ryc. 10. *1—4. Carpinus* cf. *betulus* L., × 8 (Suchoraba 21, *1;* Suchoraba 22, *2, 3;* Łapczyca 70, *4*); *5—7. Fagus* aff. *orientalis* Lipsky, × 6 (Suchoraba 20, *7;* Suchoraba 22, *5, 6); 8. Carya* sp., połówka orzecha, × 5: s — łupina, c — komora, r — kant podłużny (Liplas 16); *9. Liquidambar* aff. *orientalis* Miller., fragment owocostanu, × 12 (Suchoraba 24)

in differentiating these species. By way of orientation as distinct from detailed study, the characteristic features of the fruits have been compiled and are presented in Table 9 as well as in Fig. 11.

Table 9
Tabela 9

Details of the morphological structure of the fruits of *Fagus silvatica* L., *F. orientalis* Lipsky, and *F. grandifolia* Ehrh.
Szczegóły budowy morfologicznej owoców *Fagus silvatica* L., *F. orientalis* Lipsky i *F. grandifolia* Ehrh.

Morphological characters Cechy morfologiczne	*Fagus silvatica* L.	*Fagus orientalis* Lipsky	*F. grandifolia* Ehrh.
size of cups	up to 3 cm long	about 2 cm long	about 1 cm, specimens up to 1·7 cm long occur
shape of cups	elongate, at base cuneate-circular, at top pointed	uniformly elongate, at base cuneate-circular, at top broad and rounded	much shorter, at base clearly inflated and at top sharply narrowed
excrescences on cups	subulate, slightly converging, narrow at top	subulate, slightly converging, scapular flattening in upper half	subulate, clearly converging and regularly distributed, less abundant in lower part
external surface of cups	abundantly pilose, rough in lower part	abundantly pilose, rough in lower part	slightly pilose, smooth in lower part
thickness of cups	considerable along entire length	considerable along entire length	slight, especially in apical area
peduncle	thick, at the base of cup cuneate-dilate	thick, at the base of cup cuneate-dilate	much thinner
fruit	elongate	elongate	relatively short and broad

The species *F. orientalis*, *F. silvatica*, and *F. grandifolia* differ fairly considerably in the structure of their fruits which, however, does not mean that the determination of fossil material was easy. The difficulty consists in the fact that also in the East Asiatic species of the genus *Fagus* there occur fruit cups resembling those of *F. orientalis* (e. g. *F. crenata* Bl., *F. lucida* Rehd. et Wils.) or of *F. grandifolia* (e. g. *F. japonica* Max., *F. Hayatae* Palib.). An additional obstacle is due to there being a small chance of preservation, in the fossil state, of the scapular distensions of excrescences on the cups, which are of such diagnostic importance.

Despite these reservations I am convinced that the majority of the fruit cups coming from the Neogene floras of Southern Poland belong to the type *F. orientalis*, only their dimensions are somewhat smaller. The cup part found at Suchoraba is exceptionally large and could satisfactorily

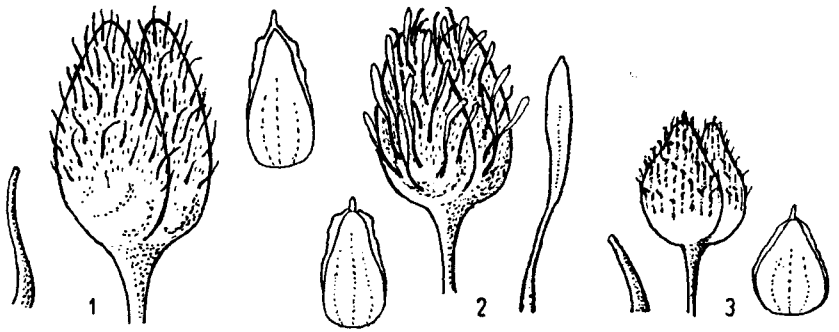

Fig. 11. Scheme of fruit structure of *Fagus silvatica* L. (*1*), *F. orientalis* Lipsky (*2*) and *F. grandifolia* Ehrh. (*3*).

Ryc. 11. Schemat budowy owoców *Fagus silvatica* L. (*1*), *F. orientalis Lipsky* (*2*) i *F. grandifolia* Ehrh. (*3*)

correspond to the mentioned species. On the other hand, the nut, though elongate, is clearly smaller than those of *F. orientalis*. It should also be added that on one fruit cup coming from the Neogene flora of Domański Wierch the scapular distension of the excrescence is preserved. In the opinion of Prof. J. Zabłocki (the 1959 lecture, cf. Kostyniuk 1959) the fruits of *F. orientalis* occur in the flora of Wieliczka.

All this points to the presence in the Polish Neogene of a form of beech if not identical with, then at least related to *F. orientalis* Lipsky.

Occurrences of the genus *Fagus* in the Miocene of Southern Poland: Kokoszyce, Stare Gliwice, Wola Duchacka (?), Swoszowice, Wieliczka, the "Gdów Bay", Domański Wierch.

Juglandaceae

Carya sp.

Fig. 10, *8*

Locality: Liplas 16

One small half fruit (11·0 × 5·0 mm.), flattened and considerably damaged, was found. The fruit is completely flat on one side and on the other slightly convex as a result of uneven compression. In longitudinal section the thick and pointed shell (s) and a part of the ventricle (c) can be seen. On one of the external sides, a longitudinal ridge (r) running archwise from the apical part to the base is noticeable.

Because of the presence of the ridge and the small dimensions, the fragment described above approximates the genus *Carya* rather than *Juglans*. Specific determination is not possible because of the poor preservation of the specimen.

The genus *Carya* was represented in the Miocene of Southern Poland by several different species of which evidence is provided by numerous fruits found at Wieliczka (Zabłocki 1928), Stare Gliwice (Szafer 1961), and Turów (Czeczott, Skirgiełło 1961).

The pollen-grains of the family *Juglandaceae* confirmed by a trial pollen analysis of the Suchoraba sample (cf. p. 12) belong to the genus *Carya* (1 per cent) and *Engelhardtia* (1 per cent).

Moraceae

Broussonetia tertiaria Dorof.

Pl. IV, 7; Fig. 12, 1

Locality: Suchoraba 22

Endocarp 1·3 × 1·8 mm. irregular in shape, somewhat flattened, with a small excrescence at the apex. The ventral side of the endocarp shows a distinct groove, the dorsal side is strongly flattened and a blunt longitudinal rib can be seen on it. The walls of the endocarp are thick and their external surface is covered with thick, flat verrucae.

Thus built endocarps occur in the genus *Broussonetia* whose 3 contemporarily living species grow exclusively in East Asia (China, Japan, Korea). Two endocarps of this kind were identified for the first time by M. E. J. Chandler from the Eocene of England (1925—26) since when considerable numbers of specimens have been confirmed by Dorofeev (1963a) from Oligocene deposits of Western Siberia.

The specimen from Suchoraba corresponds to the species *B. tertiaria* Dorof., whose endocarps — in Dorofeev's view — hardly differ from *B. papyrifera* Vent., the tree growing wild in the forests of Japan, Korea, and China and cultivated in the Caucasus and Crimea. Endocarps of the contemporary species (comparative material comes from several localities) show identical structure but have somewhat larger dimensions.

It should be added that a leaf of *Broussonetia* sp. has been reported from the Upper Miocene of Switzerland by Rüffle (1963).

Broussonetia pygmaea Dorof.

Pl. IV, 8; Fig. 12, 2

Locality: Siedlec 62

Small endocarp (1·0 × 1·2 mm.), oviform in shape, with the excrescence displaced towards the groove situated on the ventral side. The walls of the endocarp thin, verrucae on the surface relatively small and widely scattered.

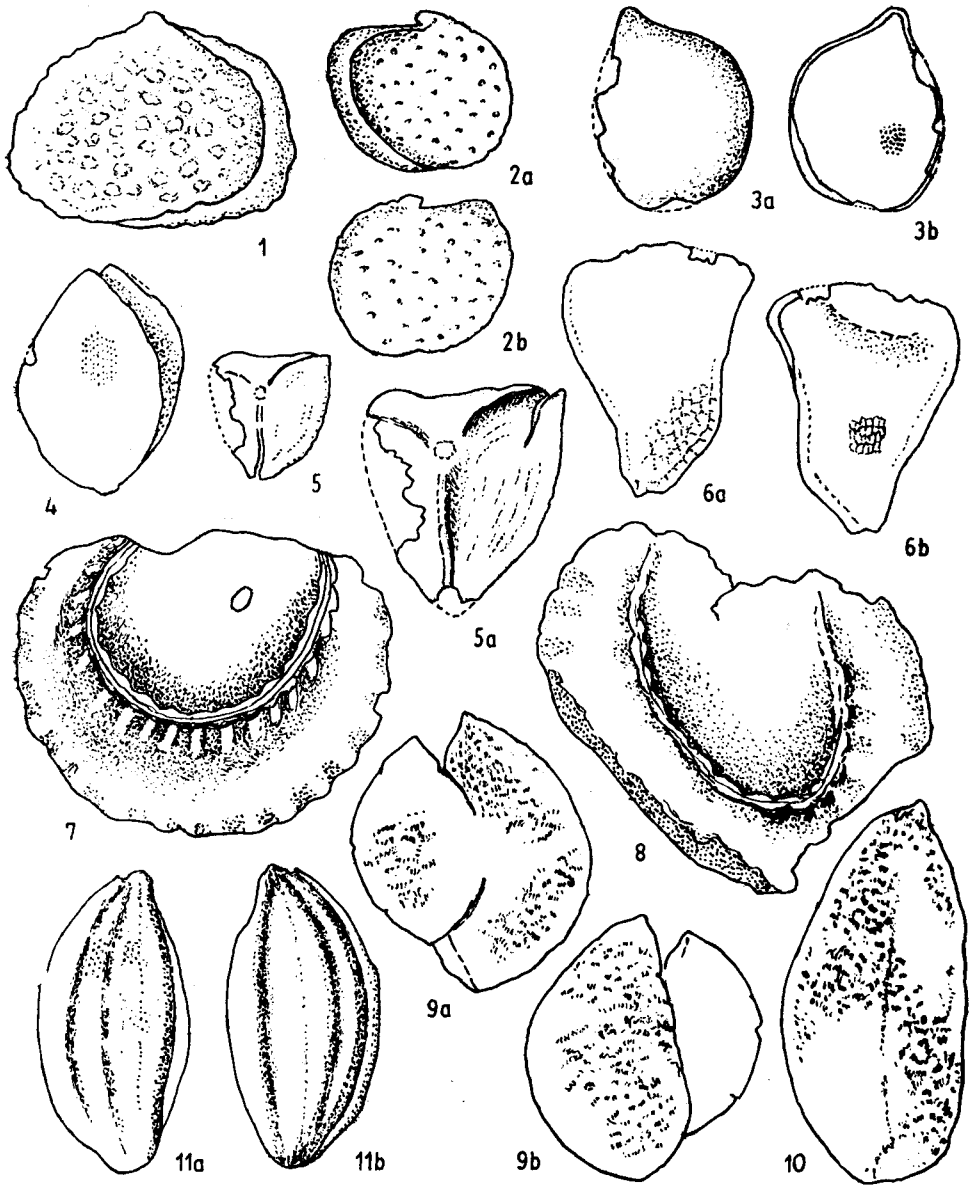

Fig. 12. *1. Broussonetia tertiaria* Dorof., endocarp, × 20 (Suchoraba 22); *2. Broussonetia pygmaea* Dorof., endocarp, × 20 (Siedlec 62); *3.* cf. *Ficus carica* L., endocarp, × 16 (Siedlec 58); *4. Rumex* sp., fruit, × 15 (Liplas 15); *5, 6.* cf. *Phyllanthus* sp., seeds (Pierzchów 27) × 16 and 28 (*5 a*); *7, 8. Sinomenium Militzeri* Kirchh., endocarps, × 10 (Sypka Góra 13, Gierczyce 66); *9, 10. Liriodendron geminata* Kirchh., seeds, × 10 (Książnice 32, Suchoraba 24); *11. Thalictrum* sp., fruit, × 25 (Kłaj 67).

Ryc. 12. *1. Broussonetia tertiaria* Dorof., endokarp, × 20 (Suchoraba 22); *2. Broussonetia pygmaea* Dorof., endokarp, × 20 (Siedlec 62); *3.* cf. *Ficus carica* L., endokarp, × 16 (Siedlec 58); *4. Rumex* sp., owocek, × 15 (Liplas 15); *5, 6.* cf. *Phyllanthus* sp., nasiona (Pierzchów 27) × 16 i × 28 (*5 a*); *7, 8. Sinomenium Militzeri* Kirchh., endo-

This fragment is identical with the remains from the Oligocene and Miocene of Western Siberia described by Dorofeev (1963a) who established the resemblance of fossil endocarps to the species *Broussonetia kazinoki* S. et Z. growing today in the mountains of Japan and South-eastern China.

The comparative material of *B. kazinoki* was not available to me but I had at my disposal several well-preserved fossil specimens of the endocarps of *B. pygmaea* which occur in the Miocene deposits of Domański Wierch.

The genus *Broussonetia* was not hitherto known from the Polish Tertiary.

cf. *Ficus carica* L.

Fig. 12, *3*

Locality: Siedlec 58

In the examined material is preserved only a half of the asymmetrical fruit (1·75 × 1·1 mm.), rounded at the base and tapering at the top to a conspicuous straight beak displaced towards the ventral side. This fruit was somewhat flattened from the dorsal side and had a longitudinal rib, this being confirmed by the manner in which the specimen had split and by the preserved fragment of its second half (Fig. 12, *3b*). The external and internal surface was decayed, with barely visible slight pitting.

The fruit is similar in shape to those of the genus *Ranunculus* but its structure is different because its ventricle extends to the very end of the apical contraction of the fruit. Ventricles of similar shape are a feature of some genera from the family *Rosaceae* (*Potentilla, Alchemilla* [1], *Comarum, Sibbaldia*) but they differ in some details of morphological structure.

With regard to morphological structure, the fragment from Siedlec corresponds to the fruits of *Ficus carica* L., which could not be confirmed by details of anatomical structure as the specimen was very poorly preserved.

In determination, of great help were the fruits of *Ficus carica* coming from the Bronze Age (Valeggio, Northern Italy) identified by M. Villaret-von Rochow. Here can be seen better than on contemporary speci-

[1] Initially, the fragment in question was ascribed to the genus *Alchemilla* (Łańcucka-Środoniowa 1963).

karpy, × 10 (Sypka Góra 13, Gierczyce 66); *9, 10. Liriodendron geminata* Kirchh., nasiona, × 10 (Książnice 32, Suchoraba 24); *11. Thalictrum* sp., owocek, × 25 (Kłaj 67)

mens — the characteristic manner of the fruits' splitting into two parts, i.e. easy and uniform from the dorsal side and uneven from the ventral one. I could also compare the specimen from Siedlec with the Miocene remains from Salzhausen identified as *Ficus potentilloides* (M a i 1964) and showing similar details as regards morphological structure with distinctly smaller dimensions. In M a i's view the same species occurs in the Miocene of Lusitia (Wiesa, Hartau) as well as in the Silesian Miocene (Nowogrodziec=Naumburg) whence it was reported by K r ä u s e l (1920, p. 381, Taf. 23) as *Potentilla* sp.

Cutaneous and preserving well in fossilisation, the leaves of the genus *Ficus* have been frequently reported, especially from Tertiary deposits. Also recorded were the fruits of the genus *Ficus* (*Ficus callosaeoides* Engelh.,? *Ficus* cf. *carica* L., *F. dombeyopsis* Unger, *F. elegans* Weber, *F. orbicularis* Engelh.) but their determination was subsequently questioned (K i r c h h e i m e r 1957). Lately, the fruits of *Ficus lucidus* have been reported from the Palaeogene of England (C h a n d l e r 1962, 1963).

The species *Ficus carica,* of interest to us, was described in 1908 by E n g e l h a r d t and K i n k e l i n from the Pliocene of Frankfurt a. Main. According to M ä d l e r (1939), this is, however, a fragment of a bulbous root. The fruits and leaves of this plant are known from the Quaternary deposits of Italy and France (G o t h a n, W e y l a n d 1964). At present, *Ficus carica* grows wild in Western Asia, and in the Mediterranean region it is one of the most important cultivated fruit trees.

The determination of the specimen from Siedlec cannot be considered as certain because of the poor preservation of the single fruit, but it has a high degree of probability.

Eucommiaceae

Eucommia ulmoides Oliv.

Pl. IV, 9

Locality: Bodzanów 1

One flat and elongate fruit, length 16·0 mm. and breadth 5·0 mm. has been preserved. On the edges, here and there lighter spots, which are traces of wings encompassing the nut, appear. In the apical part a small fragment of wing is also preserved. On the entire surface of the fruit can be seen gutta-percha fibres displayed conspicuously at points where the surface caves in. The fragment described above is undoubtedly the fruit of the genus *Eucommia* whose two species have been described from the Neogene of Poland: *E. ulmoides* Oliv. (the Miocene of Stare Gliwice, S z a-

fer 1961) and *E. europaea* Mädler (the Pliocene of Mizerna, Szafer 1952a, 1954 and the Miocene of Sośnica, Micek 1959). These two species differ in the size of the nuts which in the species *E. europaea* are somewhat larger (Mädler 1939; Szafer 1952a)[1]. The specimen from the „Gdów Bay", having a nut 16 mm. long, belongs to the species *E. ulmoides* Oliv., whose fossil and contemporary nuts have a length of 10—17 mm. and a breadth of 2—5 mm. Unfortunately this specimen has been lost but a drawing and photograph of it have been preserved.

In the same sample from Bodzanów, besides the fruit were found also two small fragments of leaves (0·5 cm.^{2}) probably belonging to the genus *Eucommia*. Individual fragments of the blade are joined with elastic gutta-percha fibres with characteristic caudal thickenings at the ends (Pl. IV, *10, 11*).

Similar fragments of leaves have been confirmed in the Miocene of Wieliczka and Zakrzów by M. Wąs (unpublished, material in the Institute of Botany of the Polish Academy of Sciences).

Polygonaceae

Rumex sp.

Fig. 12, *4*

Locality: Liplas 15

A triangular fruit 1·7 × 1·1 mm., broadly fusiform in shape. The apex of the fruit pointed, the lower part somewhat broader with a noticeable basal beak. The longitudinal edges sharp, lateral walls concave. External surface minutely pitted.

Morphological characteristics of the fruit correspond to the genus *Rumex* (Marek 1954). Specific determination of this solitary and poorly preserved fragment is not possible because fruits similar in shape and size occur in various contemporarily living species of the genus *Rumex*. This genus numbers today about 200 species and mainly occupies temperate regions of the Northern Hemisphere, more rarely zones of warmer climates.

Small fruits (1·2 — 1·7 × 0·9 — 1·1 mm.) similar in shape to the specimen from Liplas have been described by Dorofeev from the Miocene of Western Siberia as *Rumex* sp. (1963a, Tabl. XXVI, *33, 34*). He stressed

[1] A different view has recently been taken by Tralau (1963) who considers that the species *E. ulmoides* Oliv. contemporarily living in China varies very considerably in size of fruits depending upon the ecological conditions. According to this author, differentiation of species on the basis of the size of fruits alone is not fully justified.

their characteristics common to the species of the section *Hololapathum*: *R. komarovii* Schischk. et Serg., *R. fischeri* Rchb. and *R. patientia* L. This latter species should, however, be excluded as it has fruits more than twice as large (3·0 — 5·0 × 1·7 — 3·0 mm., according measurements taken by Marekin 1954). I have had no access to comparative materials of the Asiatic species *R. komarovii* and *R. fischeri*.

In the European Tertiary the fruits of *Rumex* were known till recently only from the Pliocene (Szafer 1954; Kirchheimer's list of 1957 [1]). They have been confirmed also in Miocene deposits of Western Siberia and of Ukraine (Dorofeev 1955b, 1959a, 1963a) and they probably occur in the Miocene of Stare Gliwice (Szafer 1961, p. 48).

Euphorbiaceae

cf. *Phyllanthus* sp.

Fig. 12, *5*, *6*

Locality: Pierzchów 27

There have been preserved two small fragments of dark-brown colour with somewhat translucent edges displaying — despite being poorly preserved — feature characteristic of seeds of the genus *Phyllanthus*.

The first specimen (Fig. 12, *5*) is very small (1·2 × 0·9 mm.), triangular in shape, considerably flattened and damaged. Though its triangularity is clearly distinguishable. Its dorsal wall is curved and overlaps the ventral side on which can be seen two deepened lateral walls and between them a broad longitudinal rib. At the top of this rib there is a round depression filled with silt; the lower part has unfortunately broken off. On the external surface of one of the lateral walls are seen traces of striation originating from thickened walls of cells arranged in longitudinal bands. These cells have very thick walls and large cellular lumina.

The second specimen (2·0 × 1·5 mm.) is probably the dorsal wall of a considerably larger seed. At the top it is comparatively broad (the part overlapping the ventral side (Fig. 12, *6b*) has been preserved) and at the bottom curved and narrowed. At the edges can be seen a band of characteristic large thick-walled cells which also mark the external surface of this fragment (Fig. 12, *6a*). The internal surface is covered with much smaller polygonal cells (*6b*).

[1] According to this author, the identification of fruits of *Rumex* sp. from the Oligocene of Alsatia by Quiévreux and Reid in 1937 is based on insufficient evidence.

The determination of this fragmentary material from Pierzchów was possible only because I could use for comparison some 20 well-preserved seeds of the genus *Phyllanthus* from Miocene deposits on Domański Wierch.

The fruit of *Phyllanthus haeringianus* was described as early as 1853 by Ettingshausen from the Lower Oligocene of Tyrol but the determination was questioned in 1890 by Schenk (Kirchheimer 1957). The seeds of the genus *Phyllanthus* have been found in Tertiary deposits of Western Siberia by Nikitin (*Carpolithus triquetrus* = *Cuneula triquetra, C. kireevskiana*) and Dorofeev who has described them accurately and distinguished three fossil species (*Phyllanthus triquetra, Ph. kireevskiana* and *Ph. compassica*). In the Mio-Pliocene of Konin (Raniecka-Bobrowska 1959, Tabl. XX, figs. 1—8) there has been preserved, besides seeds, also a complete fruit of the genus *Phyllanthus*, 3-ventricular with 2 seeds in each ventricle. These remains have been erroneously described as *Eurya serseminata* n. sp. (cf. p. 80).

The remains from the „Gdów Bay" correspond most closely to the species *Ph. compassica* Dorof. (the Oligocene of Western Siberia) because longitudinal sulcation is hardly visible on them. It cannot be ruled out that this poorly visible sulcation is due to strong corrosion of the specimens, hence it cannot be regarded as a satisfactory diagnostic feature.

To the genus *Phyllanthus* belong today some 500 species of trees and shrubs (there occur also floating forms similar to *Salvinia*, e.g. the Brazilian species *Ph. fluitans*) mainly spread over tropical and subtropical regions of Asia, Africa, and America (Dorofeev 1963a).

Buxaceae

Buxus sempervirens L. foss.

Pl. V, *2*, *3*

Locality: Kłaj 40, 49

In the samples from Kłaj two fragments of leaves belonging indubitably to the genus *Buxus* were found. The larger specimen is 8·5 mm. long and, somewhat below the rounded apex, 4·0 mm. broad, whereas at a distance of 8·5 mm. from the apex it is 6·0 mm. broad. The leaf has a completely smooth margin and a characteristic venation: lateral veins depart at an acute angle from the midrib and run parallel towards the leaf margin where they branch out dichotomously and form a uniform peripheral vein parallel to the margin of the blade. On the surface of the leaf can be seen several small scuta of parasitical fungi or algae. The second specimen is

much smaller (3·0 × 3·0 mm.) and more damaged but the venation typical of the genus *Buxus* is clearly visible.

Similar remains corresponding fully to the leaves of the Mediterranean species of *Buxus sempervirens* L. occur abundantly in the flora of Stare Gliwice (S z a f e r 1961).

Hamamelidaceae

Liquidambar aff. *orientalis* Miller

Pl. V, *1;* Fig. 10, *9*

Locality: Suchoraba 24

The family *Hamamelidaceae* is represented in the flora of the „Gdów Bay" by the genus *Liquidambar* of which one fragment of fruiting head, measuring 4·7 × 4·0 mm. was found. It is considerably damaged and compressed but on it comparatively large cavities can be seen, irregular in shape and filled with silt. These funnelled cavities (nests containing fruit sacs) are separated by smooth septa which have no excrescences; only a delicate furrow running longitudinally (Fig. 10, *9*) can be traced on them.

According to the observations of H. C z e c z o t t and A. S k i r g i e ł ł o (1959) the structure of septa might serve as a good diagnostic in differentiating species of the genus *Liquidambar*. Smooth septa are a feature of the species *L. orientalis* Mill. from Asia Minor while septa covered with tiny scales occur in the American species *L. styraciflua* L. (l. c. Pl. XV, fig. 5—8).

In the opinion of the above-mentioned authors fruiting heads from the Lower Miocene of Turów near Bogatynia and from Wieliczka show a considerable resemblance to *L. orientalis*. As can be seen from the description given in the introduction, the specimen from the „Gdów Bay" may also be connected with this species. Also fruiting heads from Stare Gliwice contain smooth septa. It would follow from this that in the territory of Southern Poland there grew in the Miocene a *Liquidambar* closely related to the species *L. orientalis* which today occurs only in the south-western part of Asia Minor.

H. C z e c z o t t and A. S k i r g i e ł ł o stress in their work that in the palaeobotanical literature attention has long been drawn to the similarity of the Tertiary remains of the genus *Liquidambar* to the species *L. orientalis* (C-E. M. R e i d 1915; S t r a u s 1935) or to the fact that some fossil fruiting heads described under different names should be linked to this species (G e y l e r and K i n k e l i n 1887; K i r c h h e i m e r 1943b). It may be added that the similarity of the Miocene leaves of this genus to

the leaves of *L. orientalis* has been noted by Hungarian authors (Andréanszky, Kovács-Sonkodi 1955; Andréanszky 1959) in the course of describing *L. protensa* Ung. and *L. pseudoprotensa* Andréan.

The collective species *L. europaea* A. Br., characteristic of the European Tertiary, is commonly regarded as the prototypal form of contemporary species. This conviction is to a large extent based on the observation of leaves whose considerable variability makes distinction of species difficult. Thus, for instance, in the Miocene flora of Rochessauve in Southern France (Grangeon 1958) where there occur a great number of leaves of *L. europaea*, some of them belong to the type *L. styraciflua* and others show characteristics of *L. orientalis*.

According to Makarova (1957), both these contemporary species came into being only in the Pliocene from the primordial form described as *L. europaea* A. Br. The author reaches this conclusion on the basis of an analysis of the morphology of the leaves and their epidermis. An examination of the structure of fruiting heads of *Liquidambar* from the Polish Miocene shows, however, that the origins of the development of the species *L. orientalis* might be sought already in the Miocene [1].

This species, growing today in the relict area in the south-western part of Asia Minor, occupies mainly coastal lowlands muddy in spring and dry in summer. In the mountains it reaches an altitude of 400 m. above sea level.

The genus *Liquidambar* is known in Europe from numerous older and younger Tertiary floras while it enjoyed optimal developmental conditions probably in the Miocene. Evidence for this might well be found in the list of occurrences of fossil fruiting heads of this genus compiled for Central Europe by Kirchheimer (1957) in which Miocene occurrences play the dominant role. The same can be said of the Tertiary floras of Czechoslovakia (Němejc 1949, 1951, 1953, 1962), Serbia (Pantić 1956a, b) and Hungary (Andréanszky 1959). Especially in the Hungarian Miocene remains of this genus occur in great abundance and on the basis of the morphological structure of leaves several fossil species have been distinguished. Also in the Tertiary floras of Poland the close connection of the genus *Liquidambar* with the Miocene can be observed. Fruiting heads were found in Turów (Czeczott and Skirgiełło 1959), Chłapowo (Zabłocki 1935), Wieliczka (Zabłocki 1928), Stare Gliwice (Szafer 1961), and the „Gdów Bay". The leaves occur in Sośnica and Pogalewo Wielkie = Gross Pogul (Kräusel 1920) and on Domański Wierch (Łańcucka-Środoniowa 1963).

In the Pliocene this tree probably played a considerably smaller role especially in the area of Central and Northern Europe although palynological analyses show its presence (Szafer 1954; Zagwijn 1960). Ma-

[1] In the Miocene deposits of Rypin in the Dobrzyń Lakeland there occur pollen-grains of the species *Liquidambar orientalis* (Stuchlik 1964).

croscopic remains in the form of leaves and fruiting heads were found only in Western and Southern Europe (Laurent, Marty 1923; Kirchheimer 1949, 1957; Kitanov 1956; Pantić 1956a, b; Geissert 1962; Palamarev 1964). In Bulgaria and Italy they occur in Pleistocene deposits (Kitanov 1956; Gothan, Weyland 1964).

From the Pliocene of Krościenko on the Dunajec (Szafer 1947) fruiting heads of *L. europaea* A. Br. have indeed been described but these remains, as appeared after re-inspection of the material, differ in structure from the fruiting heads of the genus *Liquidambar*. They are almost globular forms provided on the surface with semi-aculeate excrescences which are distended in the lower part and in the upper distinctly narrowed and fractured. These „excrescences" — as can be seen in one specimen (l. c. Tabl. VII, fig. 15) all open in the same manner, forming at the same time sort of „jaws" with folded over and rounded edges. Closed „excrescences", after cross-cutting the basal part, show no traces of the seminal ventricle.

Should these be fruiting heads of the genus *Liquidambar*, it would be possible to compare them only with the East Asiatic species *L. formosana* Hance in which occur no distinct septa surrounding the fruit sacs. These sacs are, however, surrounded by tightly fitting semi-sebulate scales which in the upper part are morphologically similar to fruit sacs but are considerably smaller (cf. the outline of structure Fig. 13, *1*). The specimens from Krościenko show no such differentiation since all semi-aculeate thickenings resembling sacs are uniform in size and densely packed together (Fig. 13, *2*). Moreover, these remains easily fall apart into separate

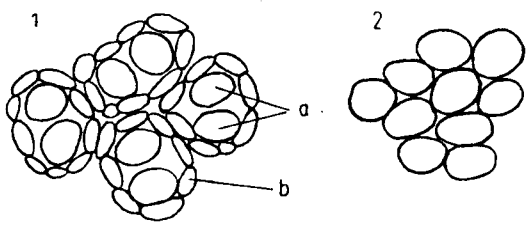

Fig. 13. Scheme of fruit structure (contiguous section) *Liquidambar formosana* Hance (*1*) and *L. europaea* A. Br. from the Pliocene of Krościenko (*2*): a — fruit sacs, b — subulate scales.

Ryc. 13. Schemat budowy owoców (przekrój styczny) *Liquidambar formosana* Hance (*1*) i L. *europaea* A. Br. z pliocenu Krościenka (*2*): a — torebki owocowe, b — łuski szydłowate

elements while in the fruiting heads of *L. formosana* this is impossible since the sebulate excrescences surrounding the fruit sacs are joined in the lower part.

The anatomical structure of the specimens from Krościenko also does not correspond to that of the fruiting heads of *Liquidambar formosana*

whose cross-section shows cells of various type: circular, oval and elongate with thick smooth walls and, apart from this, cells irregular in shape with thin smooth walls. The remains from Krościenko have an anatomical structure which is little diversified. In cross-section the outline is seen of only one type of large polygonal cells, irregular in shape and with thin undulating walls.

The specimens from Krościenko are probably zoocecidial forms which occur on the branches of the Japanese spruce, *Picea polita* Carr. Strikingly similar fossil remains are reported from the border of the Pliocene and the Japanese Quaternary in Kantengoya by Kokawa (1961, Fig. 6/c) who at the same time gives for comparison photographs of gall-flies collected at two contemporary stations. Kokawa stresses the specific character of these zoocecidia which, for instance, in *Picea jezoensis* are of different type. The zoocecidia occurring on our spruce, *Picea excelsa*, are also of different structure.

The presence of zoocecidia linked with *Picea polita* in the flora of Krościenko is likely because the remains of this spruce abound at this station in the form of needles, twig fragments, cones, and seeds. Zoocecidia on twigs of spruce were found in the Miocene flora of Chłapowo by J. Zabłocki (1936) who called attention to their similarity to „the present day cecidia caused by the plant-louse of the genus *Adelges*".

Magnoliaceae

Liriodendron geminata Kirchh.

Fig. 12, *9*, *10*

Localities: Suchoraba 24; Książnice 32

The double seed of the genus *Liriodendron* comes from the locality of Książnice. The seeds have the dimensions 3·5 × 2·0 mm. and 2·7 × 1·7 mm., characteristic shape and, visible in some places, a minutely verrucose surface sculpture. The single seed, somewhat larger and more elongate, (5·0 × 2·35 mm.), coming from the drilling at Suchoraba, probably belongs to the same genus. One of its flat surfaces is marked with a slight thickening running through the middle of the seed along its longitudinal axis. This may be the edge to which another seed adjoined.

Similar remains have been described from the Miocene of Stare Gliwice (Szafer 1961) as *L. geminata* Kirchh. The systematic position of this fossil species has not yet been satisfactorily explained. It is not known what is its relation to *L. tulipifera* L. foss., described from Pliocene floras, to the contemporary Chinese species, *L. chinense* (Hemsl.) Sarg., and the North American one, *L. tulipifera* L. (Kirchheimer 1957; Szafer

1961). According to the recently expressed opinion of D o r o f e e v (1963a), the seeds of the species *L. geminata* Kirchh., charasteristic of the Tertiary of Europe and Western Siberia, show greater similarity to the seeds of *L. tulipifera* L., than to those of *L. chinense* (Hemsl.) Sarg.

Seeds of the genus *Liriodendron* occur also in other Miocene floras in Southern Poland: Wieliczka (Z a b ł o c k i 1930, p. 229), Zakrzów, Domański Wierch (Ł a ń c u c k a - Ś r o d o n i o w a 1963).

It should be added that pollen-grains of the family *Magnoliaceae* have been confirmed in the sample from Suchoraba (cf. p. 12).

Menispermaceae

Sinomenium Militzeri Kirchh.

Fig. 12, 7, 8

Localities: Sypka Góra 13; Gierczyce 66

In the flora of the „Gdów Bay" two endocarps of the genus *Sinomenium* have been found. The first specimen was washed out in 1957 by M. W ą s from the surface sample taken by him on Sypka Góra near Gdów. This specimen, measuring 4·9 × 4·0 mm., is comparatively well-preserved. The flat endocarp has a broad (1 mm.) external crest with aculeate excrescences which are better preserved on the inner side of the crest and abraded on the outer one. On the flat wall of the endocarp can be seen an excentrically placed perforation, oval in shape.

The second specimen, measuring 5·2 × 4·3 mm., comes from the drilling at Gierczyce and is somewhat compressed laterally.

These two specimens can be ascribed to the species *Sinomenium Militzeri* described for the first time by K i r c h h e i m e r (1943a) from the Tertiary of Lusitia. It was also found in the Miocene of Stare Gliwice by W. S z a f e r (1961) who discussed at some length the differences occurring in the structure of endocarps of *S. Militzeri* Kirchh. (the species known from the Oligocene and Miocene) and of *S. Dielsi* Szafer (the species known from Pliocene floras). The characteristic that best distinguishes these species is the width of the external crest which in *S. Militzeri* amounts to 1 mm. (measured from the base of the crest to that of the apical aculeate excrescences) whereas in *S. Dielsi* it is smaller by half.

The endocarps of the fossil species show considerable similarity to the only contemporary representative of the genus *Sinomenium*, i.e. the species *S. acutum* (Thunb.) Rehd. et Wils., growing in Japan and China. This species has been determined by M i k i (1963) from the Japanese Pliocene.

Occurrences of *Sinomenium Militzeri* in the Miocene of Southern Poland: Stare Gliwice, the "Gdów Bay", Niepołomice, Chyżne.

Ranunculaceae

Thalictrum sp.

Pl. V, *4;* Fig. 12, *11*

Localities: Książnice 32; Kłaj 57

From the locality of Kłaj comes one flattened fruit (1·6 × 0·8 mm.), elongate and narrowed at the poles, asymmetrical, with deep longitudinal folds. In some places a delicately pitted surface has been preserved. From Książnice comes the second fruit (1·45 × 0·8 mm.), similar in structure but with somewhat less visible longitudinal folds.

The foregoing remains are similar to the poorly developed fruits of the species *Thalictrum flavum* L., whereas they are somewhat smaller than the well-developed specimens of this species.

The genus *Thalictrum* occurs, above all, in the Pliocene floras of Eurasia but occurrences in the Miocene ones are also known (from the Rostov area and Western Siberia, Dorofeev 1959a and 1963a) and in those from Stare Gliwice (Szafer 1961). From this latter flora has been reported one fruit of *T. Bauhini* Crantz foss. and one fruit of an unidentified species.

This genus has also been confirmed in the Miocene of Orawa (Chyżne) and on Domański Wierch.

Actinidiaceae

Actinidia faveolata C. et E. M. Reid.

Pl. V, *5*

Locality: Siedlec 63

One small fragment of the testa has been found, 1·35 × 1·2 mm. in size, and with the structure characteristic of the genus *Actinidia.* The surface of the testa is covered with small cavities 80—120 μ in diameter, elongating at its edge. These cavities are surrounded by hexagonal thickenings. As a whole, the external surface of the seed resembles a honeycomb. On the internal surface, in places corresponding to the above-described cavities, slight prominences are manifested.

The genus *Actinidia* has till recently been known in Europe only from Pliocene floras since, according to F. Kirchheimer (1957), the remains reported from older formations (Heer, Conwentz, Chandler) cannot be ascribed to this genus on account of the different structure of the testa.

From more recent investigations, however, it appears that this genus was widely spread all over Central and Eastern Europe already in the Miocene and over Western Siberia in the Oligocene and Miocene. This is confirmed by numerous seeds of *Actinidia* found both in the Miocene deposits of Poland — Stare Gliwice (Szafer 1961), Wieliczka (Kostyniuk 1959), the „Gdów Bay", Chyżne, Jabłonka, Domański Wierch (Łańcucka-Środoniowa 1963) — and in the Miocene and Oligocene deposits of Odessa, Byelorussia (Dorofeev 1955b, 1960), and of Western Siberia (Nikitin 1935; Dorofeev 1963a; Kolesnikova 1961).

Opinions are divided as far as the number of species of *Actinidia* occurring in the European Tertiary is concerned. According to Szafer (1946, 1954, 1961), there were several of them: *A. faveolata* C.-E. M. Reid (the Pliocene of Western Europe and the Nowy Targ Basin), *A. polygama* Maxim foss. (the Pliocene of the Nowy Targ Basin and the Miocene of Stare Gliwice), *A. spinosa* Szafer, and *Actinidia* sp. (the Pliocene of the Nowy Targ Basin). A similar view is taken by Dorofeev who from the Tertiary of Western Siberia has described *A. faveolata, A. spinosa, A. argutaeformis,* and *Actinidia* sp. Also Kolakovskij (1958) gives from the Pliocene on the river Duab (Georgia) the species *A. faveolata* and *A. arguta.*

According to Kirchheimer (1957), in the Neogene of Europe there occurs only one species which was described in 1915 by C and E. M. Reid as *A. faveolata.* After a review of the rich material from the Dutch Pliocene, Kirchheimer came to the conclusion that the species *A. faveolata* has seeds that are very variable both in size (1·8 — 4 mm. length) and shape (from rounded to markedly elongate forms). In addition, hexagonal cavities, irregularly distributed over the surface of the testa, are relatively small i.e. 80—120 μ in diameter.

Identically built seeds were not found by Kirchheimer among the living species of the genus *Actinidia* just as they were not found in 1915 by the Reids. Having examined the species *A. arguta, A. Kolomikta, A. lanata,* and *A. polygama* (in respect of size of cavities on the surface of the testa and of the manner of their arrangement) Kirchheimer concluded that the East Asiatic species *A. Kolomikta* (Rupr.) Maxim. — an evergreen climber often cultivated today in Europe — has seeds comparatively most like those of the fossil species *A. faveolata.* In *A. Kolomikta,* the cavities of the testa are 90—140 μ in diameter and are irregularly arranged. The seeds, however, are considerably smaller with length varying between 1·5 and 2·5 mm.

The Russian authors perceive the similarity of *A. faveolata* C.-E. M. Reid to the contemporary species *A. arguta* and *A. Kolomikta* (Kolesnikova 1961) as well as to *A. melanandra* (Dorofeev 1963a). In Tralau's view (1963) the to date attempts to determine fossil species

have not yielded positive results, this being bound up with the insignificant differentiation of seeds of contemporary species.

No doubt the seeds of *Actinidia* — the genus so characteristic of the younger Tertiary of Europe and Western Siberia and today confined exclusively to East Asiatic regions — require detailed studies.

In considering the structure of seeds of different species of *Actinidia* it is necessary to take into account yet another characteristic, a marked feature of the structure of the testa. This is the number of cavities located on each side of the flattened seed at the point of its maximum breadth, i.e. usually at half length [1]. This number is constant and peculiar to each species, which I have ascertained while examining 6 contemporary species coming from 17 different samples. Thus in the species *A. chinensis* Planch. and *A. venosa* Rehd. there are only about 10 of these cavities, in *A. polygama* (S. et Z.) Miq. about 15, in *A. arguta* (S. et Z.) Miq. and *A. melanandra* Franch. about 20, and, finally, in *A. Kolomikta* (Rupr.) Maxim. about 25.

Seeds of similar dimensions, belonging to various species of *Actinidia,* have testal cavities of diverse size, depending on whether there are 10, 15 or 25 on the line of maximum breadth of the seed. For this reason the diameter of cavities cannot be a diagnostic characteristic in discrimination of species because it is a feature dependent upon the size of the seed. In the same species small seeds must have considerably smaller cavities than large seeds, in view of the number of cavities remaining the same. The constant characteristic for a given species is the diameter of the cavities of the testa computed in relation to the breadth of seed. The same may be expressed more simply by the number of cavities located on the maximum breadth of the seed (cf. Fig. 14).

The contemporary species *A. Kolomikta*, marked by the greatest number of cavities, has at the same time the most delicate testa. A similarly subtle structure is revealed by Tertiary seeds of the genus *Actinidia* in which can be counted 20—25 cavities of the testa on the maximum breadth of the seed. Attention to this delicacy of structure was called by C.-E. M. Reid while describing for the first time in 1915 the species *A. faveolata.*

In the Tertiary floras of Eurasia there occur, however, also seeds with a markedly smaller number of cavities (about 15) on the surface, for instance, *Actinidia polygama* Maxim. from the Miocene of Stare Gliwice (Szafer 1961), *Actinidia* sp. from Krościenko (Szafer 1947), *A. argutaeformis* Dorof. and *Actinidia* sp. from the Tertiary of Western Siberia (Dorofeev 1963a), *Actinidia* sp. and *A. poolensis* Chandl. from the Oligocene of England (Chandler 1962, 1963). The above-mentioned

[1] Also Dorofeev (1963a) draws attention to this characteristic giving for *A. faveolata* 12—20 and for *A. argutaeformis* Dorof. 13—16 cavities of testa.

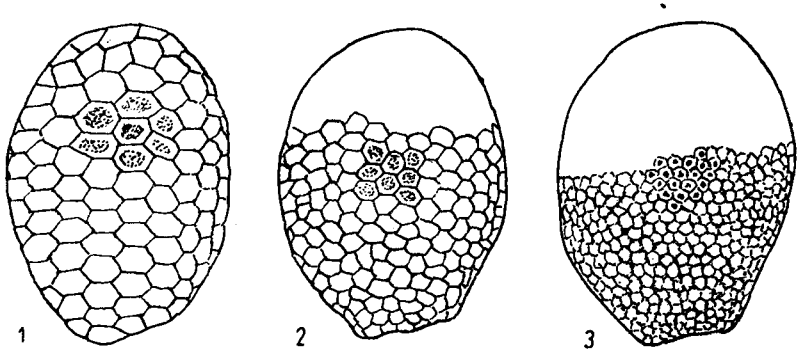

Fig. 14. Scheme of seed structure of some species of the genus *Actinidia: 1. A. chinensis* Planch. (about 10 depressions of the testa); *2. A. polygama* (S. et Z.) Miq. (about 15); *3. A. Kolomikta* (Rupr.) Maxim. (about 25).

Ryc. 14. Schemat budowy nasion niektórych gatunków rodzaju *Actinidia: 1. A. chinensis* Planch. (około 10 zagłębień testy); *2. A. polygama* (S. et Z.) Miq. (około 15); *3. A. Kolomikta* (Rupr.) Maxim. (około 25)

forms cannot be ascribed to *A. faveolata* C.-E. M. Reid because this species is characterized by a very great number of cavities of the testa.

It should be stressed that quite differently built seeds of *Actinidia* have been described by K o l e s n i k o v a (1961) from the presumably Oligocene flora on the river Ob in Western Siberia. Comparatively small seeds (1·6 — 2·0 mm. long) have on their surface very large and deep cavities of which there are only 7 along the maximum breadth of the seed. According to the author, these remains most resemble the contemporary species *A. eriantha* Benth. belonging to the section *Vestitae.* The species of this section extend farthest south for they grow in the tropical regions of South East Asia. Seeds of similar structure from the Miocene of Hartau have been described as *Actinidia* sp. (M a i 1964).

Occurrences of the genus *Actinidia* in the Miocene of Southern Poland: Stare Gliwice, Wieliczka, the „Gdów Bay", Chyżne, Jabłonka, Domański Wierch.

Theaceae

Eurya stigmosa (Ludw.) Mai

Pl. V, *6—8;* Fig. 15, *1—4*

Localities: Książnice 32, Kłaj 37, Łapczyce 74

Four strongly flattened seeds were found, with dimensions 1·4 × × 1·15 mm., 1·7 × 1·3 mm., 1·7 × 1·4 mm., and 2·2 × 1·7 mm., kidney-shaped and with a broad base. On the internal surface of the seeds there are small, somewhat elongate cavities with the longer side turned towards the centre of the seed. They are arranged in regular bands of which there are about ten running parallel to the external rim of the seed, concentric-

ally to the middle cavity which is somewhat displaced towards the base. On the surface of this middle cavity the pitting is considerably less visible, more delicate, and less regularly arranged.

The seeds tend to split in half along the longest peripheral portion beginning at the base. After section, kidney-shaped cavities become visible as well as the characteristic convexity of the two rims of the seed which run from its base to almost half the height (Fig. 15, *2b*). Moreover, in the longitudinal section it is possible to distinguish the outer layer of the testa consisting of very large horseshoe sclerenchyma cells with which the pitted sculpture of the external surface of the seed is convected.

The described remains show, it is true, some similarity in shape and structure of the testa to seeds of the family *Caryophyllaceae* and *Solanaceae* but their internal structure rules out such a comparison. Identically built seeds occur in the genus *Eurya* from the family *Theaceae*. They were determined for the first time by K o l a k o v s k i j (1958) in the Pliocene flora of Duab in Georgia where he established the presence of the species *E.* cf. *japonica* Thunb. He also remarked that seeds of the genus *Eurya* occur in the European Tertiary, that is in the Oligocene flora of Bovey Tracey in Devonshire, whence C h a n d l e r (1957) described them under the name of *Myrtospermum boveyanum, M. dubium* and *M.* sp. (Pl. 16, figs. 160—174), and in the Lower Lusitian flora of Wiese bei Kamenz. As a matter of fact, in 1960 M a i described the species *Eurya stigmosa* from the localities of Wiese and Piskowitz bei Kamenz. In both these floras the seeds of *Eurya* are frequently encountered and in 1944 they were described by L e h n e r as *Carbosemen wiesaense*. M a i considers that identical remains were determined by L u d w i g in 1860 from the Upper Miocene of Salzhausen as *Potamogeton stigmosus*.

Also the remains described by C h a n d l e r (1957) from the Oligocene of Bovey Tracey as the genus *Myrtospermum* from the family *Myrtaceae* were subsequently ascribed by this author (1960a, b) to the section *Taonabeae* from the family *Theaceae*. C h a n d l e r's observations concerning the contemporary genera of the section *Taonabeae* lead to the linking of fossil seeds not with the genus *Eurya* but rather with the genus *Cleyera*. This author introduces the name *Cleyera? stigmosa* (Ludwig) for the species whose seeds occur in great numbers and — as she herself stresses — correspond in every detail with the remains of *Eurya stigmosa* (Ludwig) Mai, described from the Tertiary of Lower Lusitia (M a i 1960).

As follows from the findings to date, the fossil species *Eurya stigmosa* occurred abundantly in the Tertiary floras of Western and Central Europe, and, moreover, persisted for a comparatively long time, from the Eocene till the Middle Miocene [1].

[1] The seeds of *Eurya stigmosa* (Ludw.) Mai have recently been found in deposits coming from the border of the Eocene and Oligocene of Ireland (W a t t s 1963) and in the Miocene deposits of Czechoslovakia (B ů ž e k, H o l ý 1962, 1964).

Fossil remains from the „Gdów Bay" fully correspond to the species described from the Tertiary deposits of Lower Lusitia. For determination purposes I had at my disposal the rich comparative material from Wiese which came from the collections of E. Schmidt from Budziszyn. It can be seen from the study of this material that fossil seeds show very considerable variation as to shape, dimensions, and size of pitting on the surface of the seeds. With great differences in shape are also connected certain variations in the course of the central cavity of the seed which has the characteristic U-shape. The fossil species *Eurya stigmosa,* characteristic of the Eocene, Oligocene, and Miocene deposits of Western Europe, has in the case of the „Gdów Bay" been confirmed for the first time in the Miocene of Poland. It occurs also in the flora of Wieliczka. One seed (1·8 ×1·6 mm.), with a well-preserved external sculpture is in the collections of the Institute of Botany of the Polish Academy of Sciences in Kraków (Pl. V, *9*).

The seeds of the species *Eurya sexseminata* described by Raniecka-Bobrowska (1959) from the Mio-Pliocene of Konin lack the characteristics typical of this genus. The course of pitting on the surface of seed is different since „the meshes of the network are arranged in longitudinal rows converging radially near the opening". The position of the hilum and micropyle is also different from that in the genus *Eurya* and, what is most important, in longitudinal section there cannot be seen the very characteristic U-shaped cavity caused by the arching of the two edges of the seed towards the centre. The remains from Konin belong to the genus *Phyllanthus* from the family *Euphorbiaceae* (cf. p. 69).

The genus *Eurya* is represented in present-day flora by considerable numbers of species living almost exclusively in the tropical and subtropical regions of South-East Asia (Indochina, Ceylon, the islands of the Malayan Archipelago) and of Central and South America (Mexico, Panama, Guatemala, Columbia, Ecuador, Peru, Bolivia). It should be pointed out, however, that several species transgress the subtropical region, extending north to China, Korea and Japan, and also south to the Sandwich Islands (in latitude 56° South).

Rosaceae

Rubus cf. *microspermus* C. et E. M. Reid

Pl. V, *10—13;* Fig. 15, *7, 8*

Localities: Książnice 32; Kłaj 39, 57

In the studied flora 8 endocarps of the genus *Rubus* were found, all characterized by small dimensions, as can be seen from the table given below:

Length in mm.	1·5	1·5	1·5	1·5	1·65	1·65	1·7	1·7
Breadth in mm.	0·85	0·9	0·95	1·05	0·85	1·1	0·7	0·85

Endocarps of this genus are known in the Tertiary floras of Europe from the Upper Eocene, from which age *Rubus acutiformis* has been described (Chandler 1925, 1926). Starting from the Miocene, the number of known forms of this genus increases in the Pliocene to 7 species, already markedly approximating contemporary species (cf. Table 10).

Table 10
Tabela 10

Species of the genus *Rubus* in the Tertiary floras of Europe (determined on the basis of endocarps).
Gatunki rodzaju *Rubus* we florach trzeciorzędowych Europy (określone na podstawie endokarpów).

Geological periods / Okresy geologiczne	*Rubus acutiformis* Chandler	R. *microspermus* Reid	*R. laticostatus* Kirchh.	*R.* cf. *pungens* Camb.	*R. idaeus* L.	*R. caesius* L.	*R. saxatilis* L. s. l.	*R.* cf. *occidentalis* L.	*R.* cf. *villosus* Ait.	*R.* cf. *fruticosus* L.
Eocene	+									
Oligocene		+								
Miocene		+	+	+	+	+	?			
Pliocene			+	+	+	+		+	+	+

The determination of contemporary endocarps of the genus *Rubus* is difficult on account of considerable variability within the sphere of individual species and also because of the great similarity of endocarps of various species discriminated on the basis of the morphology of flowers, leaves, and shoots. These difficulties are responsible for the uncertainty attaching to the determination of palaeobotanical material and not infrequently lead to a divergence of opinion. Thus, for instance, according to F. Kirchheimer (1957), the species *R. laticostatus* described by him in 1943 from Wiese bei Kamenz occurs also in the Silesian Miocene and in Pliocene deposits of Europe: in Reuver (given by C.-E. M. Reid in 1935 as *Rubus* sp. 2) and in Krościenko (described by W. Szafer as *R. caesius*). W. Szafer (1961) considers that *R. laticostatus* „belongs to the multiform group *R. caesius* L. s. l. and in the present state of knowledge it is not possible to regard it as a well-characterized and separate systematic unit".

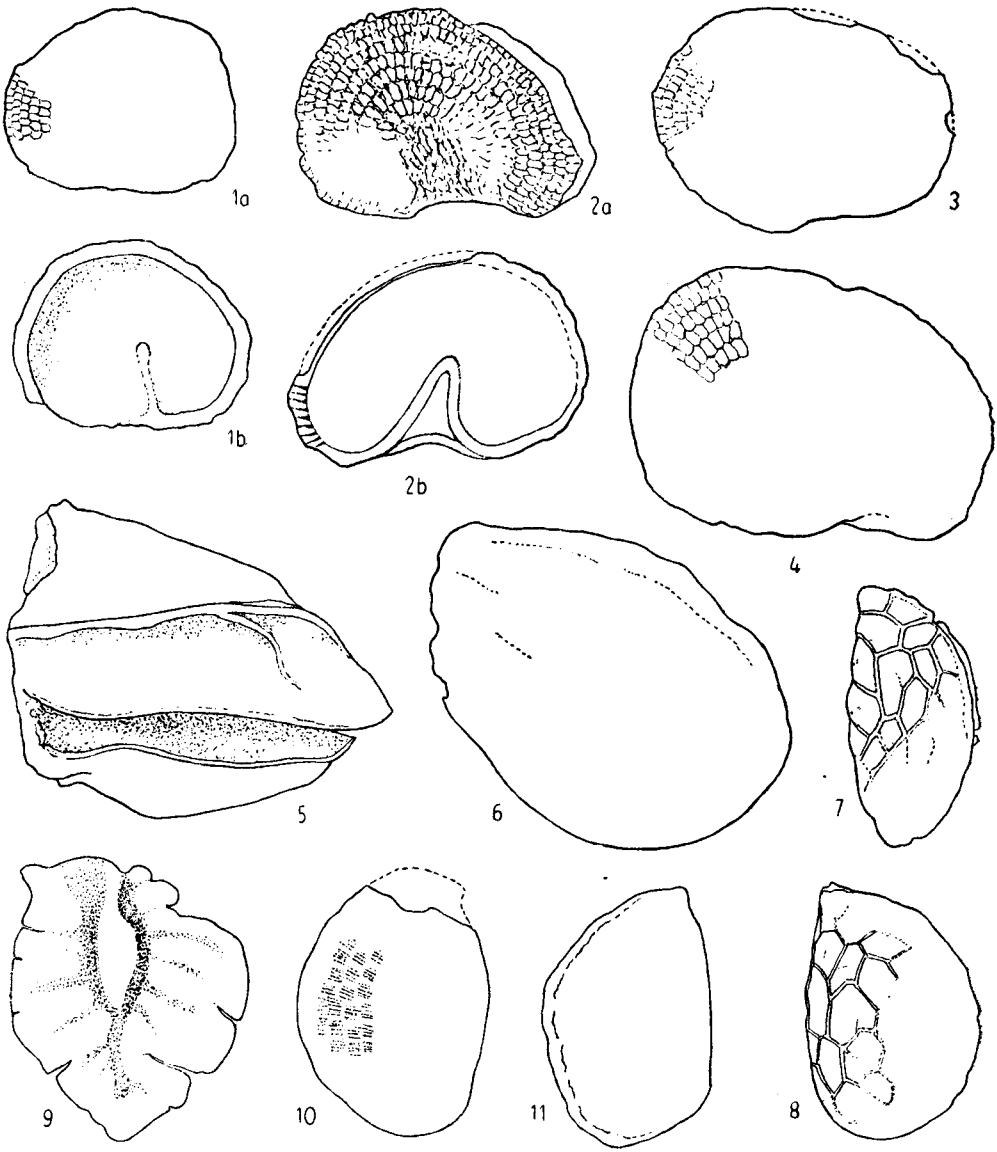

Fig. 15. *1—4. Eurya stigmosa* (Ludw.) Mai, seeds seen laterally and in longitudinal section, × 25 (Kłaj 37, *1;* Łapczyca 74, *2, 4;* Książnice 32, *3); 5. Acer* sect. *Palmata* Pax, fruit, x 16 (Siedlec 58); *6. Acer* sect. *Spicata* Pax, × 16 (Pierzchów 30); *7, 8. Rubus* cf. *microspermus* C.-E.M. Reid, endocarps, x 25 (Książnice 32, Kłaj 39); *9. Ampelopsis Ludwigii* (A. Br.) Dorof., part of seed, × 15 (Cichawa 25); *10. Aralia* aff. *hispida* Vent., endocarp, × 15 (Łapczyca 74); *11. Aralia* sp., endocarp, × 15 (Siedlec 58).

Ryc. 15. *1—4. Eurya stigmosa* (Ludw.) Mai, nasiona oglądane z boku oraz w przekroju podłużnym, × 25 (Kłaj 37, *1;* Łapczyca 74, *2, 4;* Książnice 32, *3); 5. Acer* sect. *Palmata* Pax, owoc, × 16 (Siedlec 58); *6. Acer* sect. *Spicata* Pax, × 16 (Pierzchów 30); *7, 8. Rubus* cf. *microspermus* C.-E.M. Reid. endokarpy, × 25 (Książnice 32,

The endocarps from Krościenko determined as *R. caesius* L. (Tabl. IX, figs. 28—31) show great similarity to the specimens of *R. laticostatus* from Wiese both in shape as well as in size and external sculpture. On the other hand, they differ markedly from the endocarps of *R. caesius* which species has endocarps considerably larger (up to 4 mm. long) with a narrowly elongated apex inclined towards the dorsal side. In addition, these endocarps have a prominently concave dorsal curve and the maximum breadth is situated in the lower half of the length of the seed. Of course, in the various crosses which *R. caesius* forms today with numerous species of this genus, endocarps look different and are very difficult to distinguish. So if in Pliocene floras several species are distinguished, then it is necessary to bear in mind that in these floras there may also be endocarps of crosses. On the other hand, if in a much older flora, derived from the Lower or Middle Miocene, there occurs morphologically uniform material, it seems right to distinguish it as a distinct fossil species.

In determining the endocarps of *Rubus* from the „Gdów Bay", two fossil species must be considered, *R. microspermus* Reid and *R. laticostatus* Kirchh., of which the first is characterized by particularly small endocarps (1·0 — 2·5 mm. long and 1·0 — 1·8 mm. broad). The endocarps of *R. laticostatus* are somewhat larger (1·4 — 2·6 mm. long and 1·0 — 1·6 mm. broad) although small forms may also be found among them. All the endocarps from Książnice and Kłaj are very small (1·5 — 1·7 mm. long and 0·7 — — 1·1 mm. broad) and in this respect they correspond to the species *R. microspermus*. The same is true of shape: endocarps from Książnice and Kłaj rather vary in shape from narrow and elongate to broad and rounded in the lower part. All the specimens have the inner edge straight or almost so (slightly convex) and the outer or dorsal one sharply vaulted and markedly convex. The apical portion is usually slightly elongate, which character occurs frequently in *R. microspermus*, whereas *R. laticostatus* has endocarps bluntly cut at the apex.

It remains to discuss the nature of pitting on the surface of the endocarp: in *R. microspermus* the cavities are irregular, quite large and sharp-angled rather than rounded in outline. Ridges separating cavities are thin and square. In the endocarps of *R. laticostatus* the cavities on the surface are somewhat smaller, frequently rounded, and the ridges separating them are broad. In our fossil specimens the external sculpture is poorly visible on account of damage but in some specimens it is possible to see that the cavities are irregular, sharp-angled, and rather large, and that the ridges separating them are narrow and sharp. This is especially visible in the

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Kłaj 39); *9. Ampelopsis Ludwigii* (A. Br.) Dorof., część nasienia, × 15 (Cichawa 25); *10. Aralia* aff. *hispida* Vent., endokarp, × 15 (Łapczyca 74); *11. Aralia* sp., endokarp, × 15 (Siedlec 58)

specimen from Książnice (Pl. V. *10*) whose depression contains well-preserved unabraded ridges.

As can be seen from the analysis of morphological characters, the endocarps of the genus *Rubus* found in the Tortonian of the „Gdów Bay" resemble the species *R. microspermus*, hitherto unreported from Poland, described from the Oligocene flora of Bovey Tracey already in 1910 by Mr. & Mrs. Reid (Pl. 15, figs. 13—15), and in 1957 illustrated in detail by Chandler (Pl. 14, figs. 100—109) on an abundant material. Recently this species has been described from the Miocene of Hartau (Mai 1964, Taf. XIV, Fig. 3—5).

It should be noted that the endocarps of the genus *Rubus* from the other Miocene floras of Poland, for instance from Nowogrodziec (= Naumburg, Kräusel 1920), Rypin (Łańcucka-Środoniowa 1957), Konin (Raniecka-Bobrowska 1959), and Stare Gliwice (Szafer 1961) are larger and differ in appearance.

Besides the endocarps, a thorn (sample 63 from Siedlec, Pl. V, *14*) probably belonging to the genus *Rubus* was also found. It is 2·8 mm. long with a sharply elongate apex and is 1 mm. broad at the base where a strong distension begins. The basal portion, probably of considerable dimensions, is damaged on both sides.

Aceraceae

Acer sp. 1 (sect. *Palmata* Pax)

Pl. VI, *1*; Fig. 15, *5*

Locality: Siedlec 58

Only one small fruit without the wing has been preserved. It is 4·0 mm. long and 3·0 mm. broad and of a shape characteristic of fruits of the genus *Acer*. Of the two straight veins which are clearly visible on one side, the upper vein has a delicate branch. The lower vein has split longitudinally and for a considerable distance the interior of the seminal ventricle is exposed. In this state of preservation it is impossible to determine the species but it is possible to link the described fragment with the section *Palmata*.

Of the six species belonging to this section (Pax 1902; Rehder 1958; Derevja i kustarniki SSSR 1958), as many as five grow wild exclusively in South-East Asia (*Acer polymorphum* S. et Z. = *A. palmatum* Thunb., *A. japonicum* Thunb., *A. Sieboldianum* Miq., *A. Shirasawanum* Koidz. and *A. pseudosieboldianum* (Pax) Kom. = *A. circumlobatum* Maxim.), and only one lives in the Pacific region of North America (*A. circinatum* Pursh.).

The species of the section *Palmata* have comparatively small fruits rather similar in shape and pericarpal venation. For this reason the distinction of species by fruits when the wings have not been preserved is very difficult.

In the Tertiary the section *Palaeo-Palmata* occupied in Eurasia a considerably larger area than it does today since forms undoubtedly related to this section were found not only in Europe (France, Italy, Switzerland, Hungary, Germany, Poland) but also in Altay and Kamchatka (P a x 1902; M e n z e l 1906). For the most part they were leaves compared with the contemporary species *A. polymorphum* S. et Z. In addition, under the name of *A. palmatum* Thunb., were described also fruits with the wings preserved or without them. They have been found also in the Miocene of Poland (Stare Gliwice, S z a f e r 1961).

A. palmatum Thunb. and *A. polymorphum* S. et Z. are synonyms of the species growing wild only in Japan, Korea, Central and East China and cultivated in many European gardens.

Acer sp. 2 (sect. *Spicata* Pax)

Pl. VI, *2;* Fig. 15, *6*

Locality: Pierzchów 30

Fruit 4·0 × 2·9 mm., flattened, from one side rounded and from the other obliquely cut, from which it would follow that the neighbouring fruit-wings were inclined towards each other at an angle of about 100°. One of the lateral walls is slightly convex, the another somewhat caved in. External surface smooth with only one traceable longitudinal vein running parallel to the upper edge and with traces of veins near the basal part.

Some species belonging to the section *Spicata* Pax, such as the North American *Acer spicatum* Lam., and, above all, the East Asiatic *A. ukurunduense* Trautv. Mey (= *A. caudatum* var. *ukurunduense* (Trautv. Mey) Rehd.), also have similarly built tiny delicate fruits.

Acer ukurunduense grows in conifer forests lying fairly high in the mountains of Japan and China. It extends to Sachalin, Korea, Manchuria, and Eastern Siberia (S u z u k i 1963). Leaves very closely resembling this species have been confirmed in the Pliocene of Japan and described under the name of *A. subukurunduense* n. sp. (S u z u k i , l. c. Pl. I, fig. 1).

It should be stressed that the leaves and fruits of species belonging to the section *Spicata* have been known for a long time from the European Tertiary (S c h i m p e r 1874; P a x 1902; K r ä u s e l 1919; M ä d l e r 1939; G o t h a n, W e y l a n d 1954; A n d r é a n s z k y 1959).

Vitaceae

Ampelopsis Ludwigii (A. Br.) Dorof.

Fig. 15, 9

Locality: Cichawa 25

Only one half of a seed measuring 3·0 × 2·5 mm. has been preserved. In the upper part is visible an elongate chalaza from which run off to both sides about 7 radial wrinkles and in the lower part extends to the base a furrowlike depression. The fragment is very decayed, flattened out and split, the upper part is incomplete; about the lower part it is possible to assume that it was cuneately narrowed in shape.

The described fragment corresponds to the fossil species *Vitis Ludwigii* A. Br., known, above all, from the Pliocene floras of Holland, Germany and Poland. This species occurred in Central Europe already in the Miocene: Wieliczka (Szafer 1947, 1961), Turów, (Czeczott and Skirgiełło 1959), Stare Gliwice (Szafer 1961), Randecker Maar (Rüffle 1963). Also from the Miocene deposits in the region of Rostow on the Don Dorofeev reported similar seeds under the name *Ampelopsis Ludwigii* (A. Braun) Dorof., stressing their close resemblance to the contemporary species *A. orientalis* (Lam.) Planch. and *A. Watsoniana* Wils. [1], of which grows the first in the forests of Turkey and Syria, and the second in Southern China.

Suggestions with regard to the resemblance of fossil seeds to these East Asiatic species have been current in palaebotanical writings for a long time. As Dorofeev (l. c.) mentions, already in 1915 the Reids described from the Dutch Pliocene in Reuver a seed of *Vitis* cf. *orientalis* Boiss. (= *Ampelopsis orientalis* (Lam.) Planch.). Also W. Szafer (1947), describing numerous seeds of *Vitis Ludwigii* from the Pliocene of Krościenko, called attention to their close resemblance to the seeds of *Ampelopsis Watsoniana* Wils. and to related East Asiatic species. Because of the lack of comparative material he did not solve the question finally but regarded the species *Vitis Ludwigii* A. Br. as an Asiatic element in our Pliocene, and not an American one, as had been assumed by Kirchheimer (1938). This author compared the fossil species *V. Ludwigii* to the North American vine *V. rotundifolia* Michx.

In the light of the recent studies of Miki (1956a), Dorofeev (1957c), and Kolakovskij (1958), it seems that almost all remains described as the seeds of *V. Ludwigii* should be linked with the genus *Ampelopsis*. The distinction of the seeds of the genus *Vitis* and *Ampelopsis*, although difficult, is not impossible, however, because the seeds of these closely related genera differ somewhat in the scheme of structure (cf. Fig. 16).

[1] Suessenguth (1953) following Rehder introduces for this species the name of *A. Chaffanjoni* (Lévl.) Rehd.

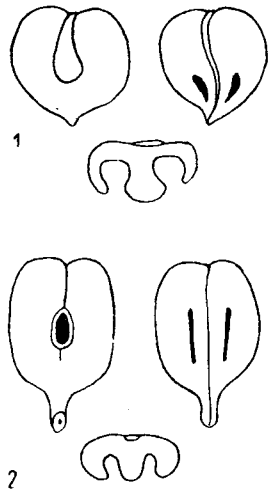

Fig. 16. Schemes of seed structure of *Ampelopsis brevipedunculata* Trautn *(1)* and *Vitis vinifera* L. *(2)* according to Miki 1956.

Ryc. 16. Schematy budowy nasion *Ampelopsis brevipedunculata* Trautn. *(1)* i *Vitis vinifera* L. *(2)* według Miki'ego 1956

In the genus *Ampelopsis* the chalaza, which is on the dorsal side of the seed, is markedly elongate in shape and gradually changes into a relatively broad cord which completely fills up the narrow furrow (as a result the seed is only slightly contracted at the apex), runs over to the ventral side of the seed and terminates only at its base. The crest in the middle of the ventral side is well pronounced so that the seed is frequently triangular in shape. The grooves situated on both sides of the crest are deep and fairly broad.

In the genus *Vitis* the chalaza is elliptical, with a tiny narrow cord running from it placed in a fairly deep furrow so that the seed is usually more contracted at the apex. On the ventral side the cord is not marked and the crest only slightly pronounced, thus the seed is more flattened. The grooves on both side of the crest are fairly deep and narrow.

With regard to the wrinkles running off radially from the chalaza, they always occur in the genera *Tetrastigma* and *Cayratia,* sometimes in the genus *Ampelopsis* (cf. Fig. 17, 5—7), but only rarely in the genus *Vitis.* Dorofeev notes that the seeds of *V. rotundifolia* Michx., with which the fossil remains of *V. Ludwigii* were compared, are considerably larger, elongate in shape and narrowly grooved. These seeds reach a length of 7—8 mm. (Fernald 1950).

Dorofeev and Kolakovskij stress that the species with strongly wrinkled seeds (*A. orientalis, A. Watsoniana, A. leoides*[1] and the fossil *A. Ludwigii*) form a separate group in the genus *Ampelopsis* and approximate, in Dorofeev's view, the genus *Cissus* and according to Kolakovskij show also traits common to the genera *Cayratia* and *Tetrastigma.* Kolakovskij even inclines to the opinion that some

[1] In Mai's view (1964) the seeds of *Ampelopsis Ludwigii* (A. Br.) Dorof. resemble most closely this South Japanese species.

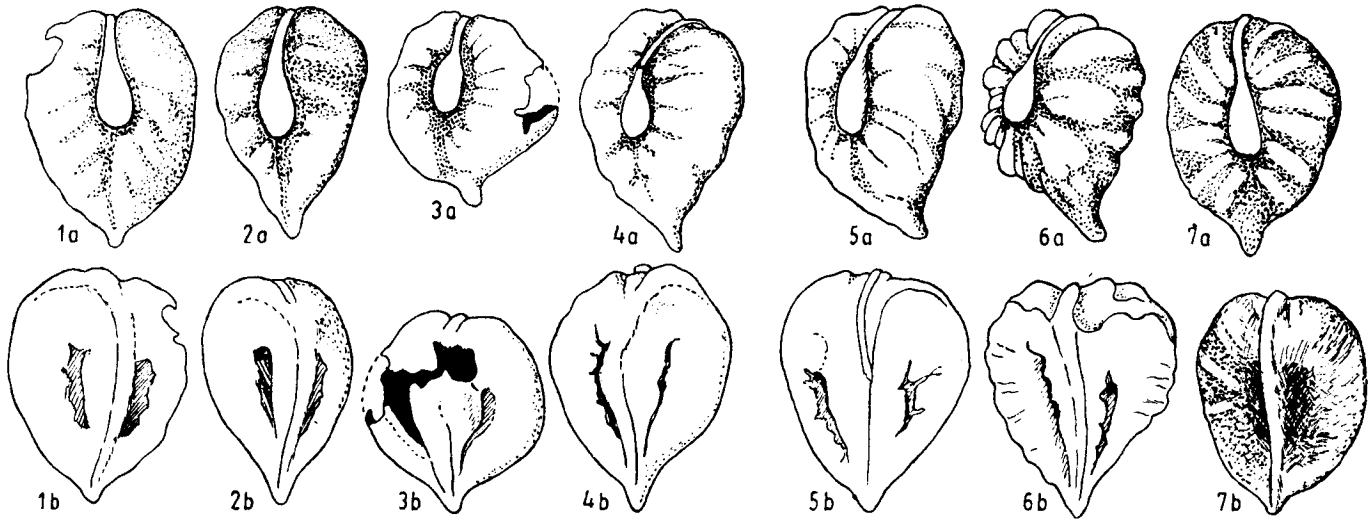

Fig. 17. *1—4. Ampelopsis Ludwigii* (A. Br.) Dorof., seeds from various Neogene localities, x approximately 9: *1* — Reuver Reid 1915), *2* — Krościenko (Szafer 1946), *3* — Rostov (Dorofeev 1957 c), *4* — Duab (Kolakovskij 1958); *5—7.* Seeds of contemporary species, x approximately 9: *5* — *Ampelopsis orientalis* (Lam.) Planch. (Dorofeev 1957 c), *6* — *A. Watsoniana Wils.* (Dorofeev 1957 c), *7* — *A. leoides* Planch (Miki 1956).

Ryc. 17. *1—4. Ampelopsis Ludwigii* (A. Br.) Dorof., nasiona z różnych stanowisk neogeńskich, × około 9: *1* — Reuver (Reid 1915), *2* — Krościenko (Szafer 1946), *3* — Rostów (Dorofeev 1957 c), *4* — Duab (Kolakovskij 1958); *5—7.* Nasiona gatunków współczesnych, × około 9: *5* — *Ampelopsis orientalis* (Lam.) Planch. (Dorofeev 1957 c), *6* — *A. Watsoniana* Wils. (Dorofeev 1957 c), *7* — *A. leoides* Planch. (Miki 1956)

different genus comes here into account. However, as he himself stresses, in the work of Suessengut (1953) concerning this taxonomically difficult family, the three above-mentioned contemporary species have been left in the genus *Ampelopsis*.

Leaves of the genus *Ampelopsis* have been noted already in Cretaceous floras and seeds were described for the first time from the Upper Eocene of England (Chandler 1925) as *A. rotundata* Chandler, a species related to the East Asiatic *A. megalophylla* Diels and *A. heterophylla* Thunb. In recent years Dorofeev has described from the Tertiary floras of the European part of the USSR and from Western Siberia, apart from the discussed *A. Ludwigii*, also several other species of this genus, among others, *A. rotundatoides* Dorof. (Dorofeev 1957c, 1959a, 1963a) with seeds very closely resembling the Eocene species *A. rotundata* Chandler but considerably smaller.

The genus *Ampelopsis* occupies today a much smaller territory than that of *Vitis* (Suessenguth 1953) since it occurs mainly in the subtropical region of Asia (Japan, China, Malayan Peninsula, the Himalayas, Asia Minor) and in addition also in the Atlantic part of North America and in Mexico. The greatest number of species falls to China.

Cornaceae

Cornus sp.

Pl. VI, *4*; Fig. 18, *1*

Locality: Suchoraba 24

Flattened fruit-stone, almost round (3·8 mm. broad and 3·7 mm. high), at the top elongated to a small blunt beak, at the base markedly rounded. On the smooth surface of the fruit-stone can be seen symmetrically placed traces of vascular bundles running archwise from the apex to the base.

Specific determination of this compressed and pyritized fragment is extremely difficult not only on account of the structural details being hardly visible but especially because in various species of the genus *Cornus* belonging to the subgenus *Thelycrania* [1], similarly built fruit-stones occur. The difficulty of determination is made still greater by the fact that in the descriptions of individual contemporary species details of the morphological structure of fruit-stones are usually given rather inaccurately and herbaria contain mainly fruits that are not fully ripe.

The specimen from Suchoraba with the bluntly elongated upper part and the rounded base, typically bent in towards the middle, shows rela-

[1] The subgenus *Thelycrania* (Wangerin 1910; Fernald (1950) is also regarded at times as a separate genus (Pojarkova 1951) or only as a section of the genus *Cornus* (Rehder 1956; Pilipienko 1960).

tively the closest resemblance to the fruit-stones of the North American species *C. femina* Mill. and *C. stricta* Lam.

The taxonomy of the above-mentioned species is very diverse. Initially, the species *C. stricta* Lam. was regarded as the synonym of *C. femina* Mill. from the subsection *Albidae* with fruit-stones 3—5 mm. in diameter, tapering to a beak and rounded and even bent inwards at the base (W a n g e r i n 1910, fig. 14/U.V; B r i t t o n and B r o w n 1913, fig. 3188). In later studies the species *C. femina* Mill. was divided into two and even three species. Because taxonomic distinction varies with different authors

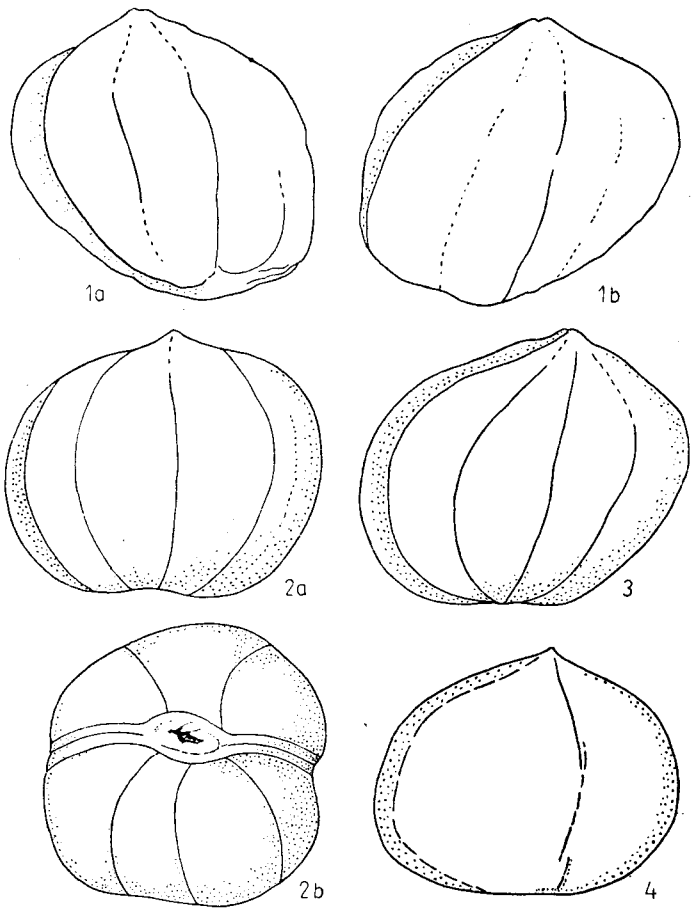

Fig. 18. *1. Cornus* sp., fruit-stone, × 16 (Suchoraba 24); *2. C. femina* Mill., fruit-stone seen from side and base, × 16 (Wangerin 1910); *3. C. candidissima* (= *C. femina* Mill. s. l.) × 16, The Botanical Garden in Uppsala; *4. C. stricta* Lam. × 16 (Britton, Brown 1913).

Ryc. 18. *1. Cornus* sp., pestka, × 16 (Suchoraba 24); *2. C. femina* Mill., pestka z boku i od strony podstawowej, × 16 (Wangerin 1910); *3. C. candidissima* (= *C. femina* Mill. s. l.), × 16, Ogród Botaniczny w Uppsala; *4. C. stricta* Lam., × 16 (Britton, Brown 1913)

(Britton, Brown 1913; Rydberg 1932; Steyermark 1954; Fernald 1950; Pilipienko 1960; Vines 1960) there is thus no uniformity in the meagre descriptions and rather inaccurate drawings of the fruit-stones.

In view of this, without good comparative material it is not possible to determine to what extent the fruit-stone from Suchoraba corresponds to the species *C. femina* Mill. or *C. stricta* Lam.

Both these North American dogwoods are associated with wet terrains since they grow on swamps and in damp thickets along streams.

The genus *Cornus* was abundantly represented in the Miocene of Southern Poland as evidenced by the rich fossil material from Stare Gliwice, Wieliczka, and Domański Wierch. In the first of these localities (Szafer 1961) 40 variously shaped fruit-stones were found of which the majority were specimens belonging to the subgenus *Thelycrania* ascribed to the species *C. alba* L. foss., *C. controversa* Hemsl., *C.* cf. *obliqua* Raf., and *C.* aff. *stolonifera* Michx.

In the Tortonian flora of Wieliczka fruit-stones of a few species of the genus *Cornus* have also been preserved (the lecture of Prof. J. Zabłocki in 1959 and Kostyniuk 1959). So far only one species called *C. salinarum* Zabł.[1] (Zabłocki 1963a) has been described as having the rather large (4·5 × 6·0 mm.) fruit-stone which, according to the author, is most reminiscent of the fruit-stones of the North American species *C. Bayleyi* Coult. et Ev. In the opinion of some taxonomists (Fernald 1950) this is not a separate species but a variety of *C. stolonifera* Michx. which has markedly broad stones.

Araliaceae

Aralia aff. *hispida* Vent.

Pl. VI, *3;* Fig. 15, *10*

Locality: Łapczyca 74

One damaged endocarp was found. Its characteristic shape and delicate parallel striation on the surface indicate its membership to the genus *Aralia*. Large dimensions (about 2·2 × 2·0 mm.), quite considerable breadth, rounded base, slight convexity of the ventral side, lack of a prominent crest on the dorsal side — all these are characteristics shared by the North American species *A. hispida* Vent.

The endocarps of this species, besides the delicate striation on the surface, show also small longitudinal creases. On the specimen from Łap-

[1] Owing to a mistake this species was not included in the list of plants identified from the Miocene of Southern Poland (Łańcucka-Środoniowa 1963).

czyca these creases are not to be seen, and the faint striation split into several small surfaces is manifested only on one side of the endocarp, the other side being smoothed and covered with small pits caused by sand grains.

Aralia hispida Vent. is a shrub that reaches a height of 1 m. and grows in the Eastern part of North America on forest clearings or rocky and sandy locations (F e r n a l d 1950). This species has been confirmed in the Pliocene of Mizerna (S z a f e r 1954, Tabl. XIII, fig. 14) and in the Russian Pliocene (K o l a k o v s k i j 1958, Tabl. XXI, fig. 16).

In the leafy floras of the Tertiary the genus *Aralia* has on the whole been not often distinguished. From the area of interest to us, it is possible to mention only the leaf of *A.* cf. *angustifolia* Kolak. recently described from Swoszowice (I l j i n s k a j a 1962). A considerable number of species have, on the other hand, been described on the basis of the structure of endocarps by the English (R e i d 1920, 1923), Polish (S z a f e r 1954, 1961), and Russian (D o r o f e e v 1955b, 1962, 1963a; K o l a k o v s k i j 1958; K o l e s n i k o v a 1961) palaeobotanists. Without going into details of a taxonomic nature or estimating whether there was a sufficient basis for distinguishing such a large number of species, it is possible to state that in the younger Tertiary of Europe and Western Siberia there occurred aralias similar to the contemporary North American species (*A. hispida* Vent., *A. racemosa* L., *A. nudicaulis* L.) as well as the East Asiatic ones (*A. Thomsoni* Seem., *A. cordata* Thunb., *A. mandschurica* Rupr. et Maxim., *A. cachemirica* Done, *A. chinensis* L. and *A. continentalis* Kitag).

The endocarps of *Aralia* sp. div. have been found in many Miocene deposits of Southern Poland: Wieliczka (K o s t y n i u k 1959), Stare Gliwice (S z a f e r 1961), the „Gdów Bay", Niepołomice, Skopanie, Domański Wierch (Ł a ń c u c k a - Ś r o d o n i o w a 1963).

In palaeobotanical writings descriptions are also to be found of complete aggregate fruits of the genus *Aralia* (R e i d 1915; S z a f e r 1946, 1954, 1961). A detailed examination of these remains has shown that in the majority of cases they are coprolites of butterflies (Ł a ń c u c k a - Ś r o d o n i o w a 1964). They have 6 longitudinal grooves on the surface, the characteristic sexcogged-wheel shape, and an amorphous inner structure.

Aralia sp. 1

Fig. 15, *11*

Locality: Siedlec 58

Aralia sp. 1 is represented by one fairly large endocarp (2·6 × 2·7 mm.) on which the characteristic crest on the dorsal side can clearly be seen, whereas the delicate striation on the surface is not visible.

Specific determination of this solitary and poorly preserved specimen is very difficult. Although endocarps similar in shape occur in the North

American species *Aralia racemosa* L. (Kolesnikova 1961), they have no prominent crest. Such crests occur mainly in East Asiatic forms.

A similarly built, though smaller, endocarp has been described from the Pliocene of Duab in Abchasia under the name of *A. cf. hypoleuca* Presl. by Kolakovskij (1958 Tabl. XXI, fig. 15) who noted its similarity to *A. hypoleuca* Presl. growing in the Philippines. Very similar endocarps, having prominent crests, are given by Dorofeev from the Tertiary floras of Western Siberia as *A. tertiaria* (Biostratigrafija, 1963, t. I, ris. 110; Dorofeev 1963a, Tabl. XLIII, figs. 35—38), a species related to the East Asiatic *A. continentalis* Kitag. The fragment from Siedlec has a more elongate apex than the specimens of Kolakovskij and Dorofeev; moreover, its external structure is entirely abraded and thus specific determination is not possible.

cf. **Primulaceae** gen.

Fig. 19, 7

Locality: Kłaj 46

Seed small (1·1 × 0·8 mm.), irregularly polygonal in shape, somewhat convex dorsally and flat or asymmetrically folded ventrally. In the middle of the ventral side there is a longitudinal eminence (*hilum*) from which to the periphery run rows of polygonal, fairly large cells. On the margin of the seed these cells form a uniform, slightly translucent band that is brown in colour.

Such small scutiform seeds occur in the family *Primulaceae* and are known from Pliocene (Reid 1920c; Nikitin 1957), Miocene (Nikitin 1935; Dorofeev 1955b, 1963a; Raniecka-Bobrowska 1959) and Oligocene deposits (Chandler 1957).

The seed from Kłaj approximates most closely the genus *Androsace* which has been distinguished by Dorofeev from the Miocene of Western Siberia (1963a, Tabl. XLV, *25;* Ris. 33, *6*).

Ericaceae

cf. ***Arctostaphylos*** sp.

Pl. VI, *5;* Fig. 19, *1*

Locality: Suchoraba 20

One elongate, rather large fragment corresponding in structure to the endocarps of the genus *Arctostaphylos* was found. It is 5·7 mm. long and 2·6 mm. broad, at the base obliquely truncated and pointed at the top. Lateral walls flat, wedging away towards the ventral side which has one straight edge. The dorsal side is rounded and has three marked edges of

which the middle one possesses a sharp longitudinal rib (Fig. 19, *1c*.) Throughout the length of this dorsal rib, the endocarp is split.

The walls of the endocarp are thick. The external surface of lateral walls is marked — though very indistinctly — with small parallel striae running obliquely to the dorsal axis, whereas the external surface of the dorsal wall is irregularly pitted. The external layer of one of the lateral walls is in part corroded and in this place thick, slightly undulating parallel striae are exposed (Fig. 19, *1a*). They are probably elongate cells of the very hard endocarp. The only specimen, strongly pyritized, crumbled during cutting and it was not possible to study details of its anatomical structure. For this reason, the generic determination is not certain.

The genus *Arctostaphylos* numbers today some 50 species of shrubs with evergreen, leathery leaves. They grow mainly in dry coniferous forests, especially pine forest, extending at times to considerable altitudes. The principal region of their distribution is North America, in particular California and Mexico. Only two species grow also in Europe, i.e. *A. uva-ursi* L. and *A. alpina* Spreng.

The fragment found at Suchoraba differs from the two above-mentioned species both in considerably larger dimensions and in more elongate shape. It probably belongs to some completely different species. It is worth noting that though this fragment approximates in shape and dimensions the endocarps of the genus *Acanthopanax* of the family *Araliaceae* yet the endocarps of this genus have only a narrow crest on the dorsal side.

The endocarps of *Arctostaphylos uva-ursi* are known from numerous Quaternary floras of Europe and the leaves of this species have been described from the Pliocene of Bulgaria (Stefanoff, Jordanoff 1935, p. 127). The other species of this Old-Tertiary genus of Pacific American origin (Hegi V/3) have not so far been reported from the Tertiary. It is necessary to stress, however, that the fruits, frequently and abundantly occurring in the European Tertiary, described as the extinct genus *Arctostaphyloides,* are very closely related to *Arctostaphylos* since from its subgenus *Xylococcus* [1] they differ only in the histological structure of the endocarp (Kirchheimer 1936).

Epacridaceae

Epacridicarpum cf. *mudense* Chandler

Pl. VI, *6;* Fig. 19, *2*

Locality: Gdów 9

A part of the globular fruit 2·0 mm. high and 2·1 mm. broad has been preserved. On the internal side, the fibrous longitudinal axis runs through

[1] Recently, a separate genus *Xylococcus* has been isolated (Abrams 1951; Mc. Minn 1959).

the middle, and the walls are visible of the two concave locules covered with smooth large cells which give the impression of a granular texture. The convex external surface is porous and covered with numerous irregular pits.

Similar remains abound in the Miocene flora of Chłapowo (several hundreds of specimens are to be found in the Palaeobotanical Museum of the Institute of Botany of the Polish Academy of Sciences in Kraków) and it is thus possible to reproduce the structure of the complete fruit. These globular fruits, 1·0 — 2·7 mm. in diameter, somewhat flattened at the poles, have usually 5 (exceptionally 4) locules which easily split longitudinally and the fruits separate into component segments. The locules are usually empty; sometimes only traces of placentae located in the apical part can be seen.

Fruits identical in structure were described for the first time by M. E. J. Chandler (1926, Pl. VI, figs. 7a, b) from the English Eocene under the generic name of *Andromeda* (?). Those found later in several Oligocene floras were ascribed to the extinct genus *Epacridicarpum* (Chandler 1960a, 1961, 1963). According to M. E. J. Chandler the structure of these fruits displays traits characteristic of the order *Ericales*, and they should be linked rather with the section *Stypheliae* of the family *Epacridaceae* (one-seed locules) than with the family *Ericaceae*.

In the English Oligocene two species *E. headonense* Chandler and *E. mudense* Chandler have been distinguished; they differ insignificantly in size and type of the external surface. The specimen from Gdów exceeds in dimensions the largest specimens described from England (the fruits of *E. mudense* Chandler are 1·1 × 1·45 mm. in diameter) since it is 2·0 × × 2·5 mm. in diameter. Fruits of this size occur fairly frequently in the material from Chłapowo.

The family *Epacridaceae* would be something of a stranger in the Tertiary flora of Europe because today its representatives are to be found mainly in Australia. E. M. J. Chandler (1961) stresses that some genera of this family grow also in India, South America, and on the sandy heaths of the Malay Peninsula.

It should, however, be borne in mind that the fruits described as the genus *Epacridicarpum* have many characteristics in common with those of the genus *Arctostaphyloides* from the family *Ericaceae* (Kirchheimer 1936) which also disintegrate easily along splitting locules. These locules, covered with typical granular sculpture, contain single seeds attached to the apical placenta. The number of locules varies: F. Kirchheimer gives for the species *A. globula* 5—10 locules and for *A. Menzelii* 5—6. In this latter species the fruits, 3·0—6·0 mm. in diameter, contain as a rule 6 one-seed locules which number, however, never occurs in the genus *Epacridicarpum*.

Only detailed studies will throw light on the extent to which the

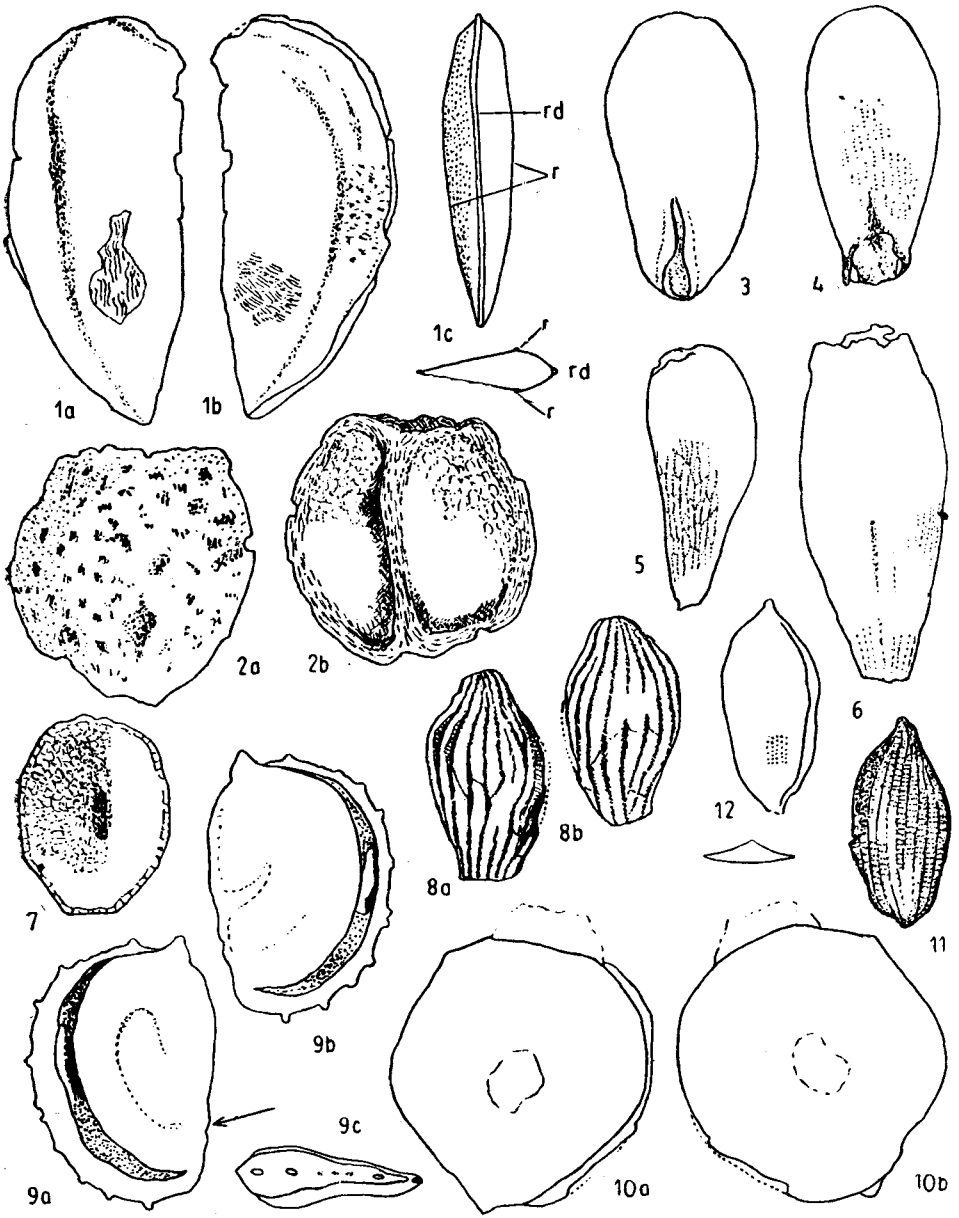

Fig. 19. *1.* cf. *Arctostaphylos* sp. (Suchoraba 20): *1 a, b* — endocarp seen from two sides × 9, *1 c* — scheme of structure of dorsal side and cross-section (rd — dorsal rib, r — longitudinal ridge); *2. Epacridicarpum* cf. *mudense* Chandl., part of fruit from external (*2 a*) and internal (*2 b*) sides, × 16 (Gdów 9); *3, 4. Labiatae* gen. div., nutlets × 25 (Kłaj 55); *5.* cf. *Artemisia* sp. fruit, × 35 (Kłaj 44); *6. Compositae* gen., fruit, × 15 (Łapczyca 74); 7. cf. *Primulaceae* gen., seed, × 25 (Kłaj 46); *8. Scrophulariaceae* gen., seed seen from two sides, × 45 (Kłaj 44); *9. Potamogeton aff. pygmaeus* Chandl., × 25 (Pierzchów 27): *9 a, b* — fruit-stone from two sides, the arrow denotes the place where the thorn probably was; *9 c* — fruit-stone seen from

fossil genera *Arctostaphyloides* and *Epacridicarpum* are related to each other. For such studies the material from Chłapowo is eminently suitable, as besides hundreds of fruits identical with the genus *Epacridicarpum* it contains, in like quantities, the fruits of *Arctostaphyloides globula* Kirchh. and *A. Menzelii* Kirchh. In the English Tertiary there probably occurred also the genus *Arctostaphyloides* Kirchh. since the fruits of *A. globula* and *A. Menzelii* closely resemble the remains described as *Carpolithus* sp. (Chandler 1960a, Pl. 35, figs. 165—167 and Chandler 1963, Pl. 24, figs. 9 and 12—17).

Scrophulariaceae gen.

Pl. VI, 7; Fig. 19, 8

Locality: Kłaj 44

The tiny (0·6 × 0·3 mm.) fragment found in the sample from Kłaj is fusiform in shape, cut off in the basal part, at the apex bluntly pointed and with the surface containing about 18 thin longitudinal ribs. In some places can be seen delicate ridges connecting the ribs with one another, varying in thickness, and here and there somewhat tall in appearance. The majority of cavities between the ribs are filled up with silt.

The described fragment closely resembles in shape and size the seeds of the genus *Sedum* (the family *Crassulaceae*) and especially the species *S. Cepaea L.*, belonging to the section *Epeteium* Boiss. (cf. Beijerinck 1947, fig. 337). A closer analysis of the structure of ribs has shown, however, that it cannot be the genus *Sedum* since its seeds never have oblique ridges connecting the ribs.

Similarity in the type of ribbing is to be observed, on the other hand, in the case of seeds of certain genera of the family *Scrophulariaceae*. In

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above, bases of thorns are visible on the lid; *10. Potamogeton* cf. *heinkei* Mai, at top of fruit-stone a membranous fragment of the seed is visible, × 25 (Łapczyca 74); *11. Juncus* sp., seed, × 43 (Kłaj 53); *12.* cf. *Cyperus* sp., fruit, × 16 (Kłaj 39).

Ryc. 19. *1.* cf. *Arctostaphylos* sp. (Suchoraba 20): *1 a, b* — endokarp widziany z dwóch stron, × 9, *1 c* — schemat budowy strony grzbietowej i przekroju poprzecznego (rd — żebro grzbietowe, r — krawędź podłużna); *2. Epacridicarpum* cf. *mudense* Chandl., część owocu od strony zewnętrznej (*2 a*) i wewnętrznej (*2 b*), × 16 (Gdów 9); *3, 4. Labiatae* gen. div., rozłupki, × 25 (Kłaj 55); *5.* cf. *Artemisia* sp., owocek, × 35 (Kłaj 44); *6. Compositae* gen., owocek, × 15 (Łapczyca 74); *7.* cf. *Primulaceae* gen., nasienie, × 25 (Kłaj 46); *8. Scrophulariaceae* gen., nasienie oglądane z dwóch stron, × 45 (Kłaj 44); *9. Potamogeton* aff. *pygmaeus* Chandl., × 25 (Pierzchów 27): *9 a, b* — pestka z dwóch stron, strzałka oznacza miejsce, gdzie prawdopodobnie znajdował się kolec; *9 c* — pestka oglądana z góry, na wieczku widoczne nasady kolców; *10. Potamogeton* cf. *heinkei* Mai, w górze pestki widoczny błoniasty fragment nasienia, × 25 (Łapczyca 74); *11. Juncus* sp., nasienie, × 43 (Kłaj 53); *12.* cf. *Cyperus* sp., orzeszek, × 16 (Kłaj 39)

the genera *Euphrasia* and *Odontites* the relatively tall longitudinal ridges are sometimes connected with oblique anastomoses but the seeds are larger and more asymmetrical. In the genus *Bellardia* [1] such anastomoses are frequent and the size of the seeds corresponds to the specimen from Kłaj but the shape is different. Among the accessible comparative material I have been unable to find the genus which could unreservedly be compared with the fossil fragment from Kłaj.

The remains of the family *Scrophulariaceae* are as yet little known from deposits older than the Pliocene. Raniecka-Bobrowska (1959) found up to a hundred seeds of *Veronica* sp. in the Mio-Pliocene flora of Konin.

Labiatae gen. div.

Pl. VI, *8;* Fig. 19, *3, 4*

Locality: Kłaj 55

One small elongated nutlet (1·6 × 0·8 mm.), rounded at the apex, somewhat narrowed at the base where a small hilum can be seen gradually turning into a narrow and elongated depression (Fig. 19, *3*).

In the family *Labiatae* the genus *Melissa* has a similarly built base of the nutlets which are dorsally convex (are steeply vaulted ventrally), and have the characteristic surface sculpture which makes the nutlets rough. Yet these characteristics are not visible in the very compressed and damaged fossil specimen.

The genus *Melissa* has so far been known in the fossil state above all from the Pliocene deposits of Holland and Germany (Reid 1915, 1920; Mädler 1939), whence have been described the nutlets of *M. elegans* Reid (resembling the East Asiatic species *M. parviflora*) and of *M.* cf. *officinalis* L. (similar to the species occurring today in the Mediterranean region). From the English Oligocene (Reid, Chandler 1926) there has been given under the name *M. parva* one small nutlet (1·25 × 0·5 mm.) with an ill-defined external structure. In his critical review of Tertiary fruits and seeds Kirchheimer (1957) casts doubt on the correctness of this determination. It is true, the irregular shape of the nutlet and its considerable breadth in the basal part (l. c. Pl. VIII, figs. 15 and 16) may raise doubts.

The second nutlet found in the same sample from Kłaj measures 1·5 × 0·7 mm. (Fig. 19, *4*) and is very delicate and translucently brown. It is markedly narrowed at the base where the rather large, partly torn apart, hilum is located. On the external surface of the nutlet, longitudinal striae are visible.

[1] Comparative material of *B. Trixago* Alles came from the Botanical Garden in Coimbra (Portugal).

This nutlet is reminiscent in its morphological structure of the nutlets of the genus *Lycopus* if one takes into account the nutlets alone, without the coat of spongy, highly perishable tissue that surrounds them (cf. the drawing of *Lycopus antiquus* E. M. Reid in Dorofeev 1963a, Ris. 35, 5).

The family *Labiatae* is as yet scantily represented in floras older than the Pliocene, with the exception of Russian floras where the nutlets have been distinguished of *Ajuga*, *Lycopus*, *Mentha*, *Perilla*, *Stachys*, and *Teucrium* (Dorofeev 1959c, 1960a, 1963a; Kolesnikova 1961).

Occurrences of *Labiatae* gen. div. in the Miocene of Southern Poland: Stare Gliwice, the "Gdów Bay", Domański Wierch.

Caprifoliaceae

Sambucus sp.

Pl. VI, 9

Localities: Łapczyca 70; Dąbrowica 76

Two fragments of the seed with the testa indented in the manner characteristic of the genus *Sambucus* were found. The seed from Dąbrowica was about 1·3 mm. broad and had a rather narrow and smooth base; the seed from Łapczyca was somewhat broader.

From the deposits older than the Pliocene of the Tertiary of Europe and Western Siberia several fossil species (*S. parvula* Chandl., *S. pulchella* Reid, *S. lucida* Dorof., *S. mudensis* Chandl.) have been described and also remains corresponding to the contemporary species *S. ebulus* L. and *S. nigra* L. have been identified.

The specimens found at Dąbrowica and Łapczyca have transverse notches fairly densely packed together but they are too fragmentary to allow of specific determination.

Occurrences of *Sambucus* sp. div. in the Miocene of Southern Poland: Wieliczka, Stare Gliwice, the "Gdów Bay", Zakrzów, Morsko, Chyżne, Domański Wierch.

Compositae

cf. *Artemisia* sp.

Pl. VI, *10;* Fig. 19, 5

Locality: Kłaj 44

Elongate achene (1·0 × 0·4 mm.), somewhat bent and markedly distended in the upper part, narrowing cuneately towards the base and truncate. On the rounded apex of the achene can be seen an asymmetric-

ally located edge which is unfortunately damaged. Surface creased undulately, the delicate longitudinal creases shining brightly.

Similarly built achenes are encountered in some species of the genus *Artemisia*, e. g. *A. absinthium* L. (Eurasia), *A. pontica* L. (Europe, Caucasus), *A. frigida* Willd. f. *montana* (Siberia, North America). The determination is not certain because of the damage to the upper part of the achene.

Though the achenes of the genus *Artemisia* sp. reported by Wessel and Weber in 1856 from the brown coals on the Lower Rhine have been mentioned in palaeobotanical writings, these remains, variously described by different authors (Shimper 1874), have recently been ascribed by Weyland (1948) to the family *Dilleniaceae* and described as *Dilleniaecarpum rottense*. Pollen-grains of the genus *Artemisia* have been distinguished in Tertiary deposits from the Oligocene to the Pliocene (Osnowy paleontologii, 1963; Stuchlik 1964).

Achenes of the family *Compositae*, frequent in Pliocene deposits, are known also from Oligo- and Miocene floras. Heer (1856) described them from the Upper Miocene of Oeningen under the name of *Cypselites* and *Bidentites*, and Ettingshausen (1868) from the Miocene of Schönegg and the Oligocene of Bilin as the genus *Hyoserites*. The achenes of *Taraxacum leporimontanum* occur in the Tertiary of Wiese b. Kamenz (Kirchheimer 1957), the achene of *Crepis* sp. in the Mio-Pliocene of Konin (Raniecka-Bobrowska 1959), and those of *Crepis* sp. and *Cirsium* sp. in the Miocene of Western Siberia (Dorofeev 1963a).

It should be noted that pollen-grains of the family *Compositae* were confirmed in the pollen analysis of the sample from Suchoraba.

Compositae gen.

Fig. 19, *6*

Locality: Łapczyca 74

Elongate achene (3·0 × 1·3 mm.), considerably flattened, slightly bent, broadest above the half-length, markedly narrowed at the base, broad at the top and somewhat obliquely truncated, the apical edge poorly developed. Surface almost smooth, minutely pitted with traces of longitudinal furrowing. One side of the achene is conspicuous for the delicate longitudinal ridge that runs through the middle, thus it was probably steeply vaulted on this side.

The morphological structure of the achene indicates the genus *Cirsium*. The achene of *C.* cf. *oleraceum* (L.) Scop. and *C. palustre* (L.) Scop. have been described from the Pliocene of Mizerna (Szafer 1954, Tabl. XVI, figs. 8 and 10). An achene somewhat smaller (2·2 × 1·2 mm.) than the

specimen from Łapczyca was found by Dorofeev in the Miocene of Western Siberia (1963a, Tabl. XLIX, 9) and given as *Cirsium* sp. with its similarity to the species *C. palustre* (L.) Scop., *C. rivulare* (Jacq.) All. and *C. heterophyllum* (L.) All. being stressed.

The specimen from Łapczyca is unfortunately damaged in its upper part and therefore even generic determination cannot be quite certain.

MONOCOTYLEDONES

Potamogetonaceae

Potamogeton aff. *pygmaeus* Reid

Pl. VI, *11;* Fig. 19, 9

Locality: Pierzchów 27

Fruit-stone very small (1·3 × 1·0 mm.) slightly oviform, laterally flattened, on the dorsal side slightly concave. Below the half-length the trace of a knob or a thorn base is distinguishable and in the upper part, on an extension of the ventral edge, there is a small beak, straight and rather broad at the base. The dorsal side convex with a broad lid (the germinal valve) extending to the base of the upper beak. The lid has a well-defined keel, on which are the bases of 9 broken thorns. The wall of the endocarp is thin.

The specimen from Pierzchów is very similar to the species *P. pygmaeus* described by M. E. J. Chandler (1925, 1961) and Reid and Chandler (1926) from the Upper Eocene and Oligocene of England. It is not, however, identical with it since its dimensions are 0·2 mm. larger and it is not known whether it had a well-defined beak on the dorsal side.

No contemporary counterpart has been found for this Tertiary species. According to Chandler (1925), nearest, though somewhat larger (1·5 × × 1·0 mm.), are the fruit-stones of *P. cristatus* Regel et Maack living today in China and Japan. In Dorofeev's opinion (cf. Chandler 1961; Dorofeev 1963a), one can perceive greater similarity to the fruit-stones of the North American species *P. spirillus* Tuckern.

I had no comparative material of *P. cristatus* but judging from figures given in the works of Miki (1953, 1961), who has described this species from 8 fossil stations in Japan, it has very small fruit-stones, at most up to 1·5 mm. in diameter, with the central depression circular in shape and a small number (5) of thorns on the germinal valve. The specimens of *P. pygmaeus* from the English Tertiary have the lateral or central depres-

sions elongate in shape and shifted towards the dorsal side of the fruit-stone (Chandler 1961). The number of thorns on the germinal valve was probably greater in this species (about 8).

The North American buckwheat *P. spirillus* Tuckern has small rounded fruit-stones with the embryo always coiled and thus revealing neither the central nor lateral depression. They are quite differently built and it is not possible to link them with the fossil species *P. pygmaeus* in spite of some similarity due to small dimensions and the presence of thorns on the keel of the germinal valve.

It would seem, therefore, that the fruit-stones of *P. pygmaeus* Chandler correspond in the comparatively greatest measure to the East Asiatic species *P. cristatus* Regel et Maack, though they are not identical with it. As has been mentioned above, the species in question differ in the number of thorns on the germinal valve and in the nature of the depressions (lateral or central).

Without special biometric studies on suitable comparative material it is difficult to judge whether the presence of the central or lateral depression, i.e. the shape of the embryo (cf. Fig. 20) is a characteristic constant in individual species or whether it is not, for instance, connected with the degree of maturity of the fruits. In keys for determining the fruit-stones of the genus *Potamogeton* this characteristic plays a minimal part (Jessen 1955) or is even not taken into account at all (Mądalski 1949). The recent works of Miki (1961) prove that this author draws attention to the shape of the embryo in different species of *Potamogeton*. At any rate, the coiling of the embryo is a constant characteristic and has been the basis of distinguishing as a separate group 4 North American

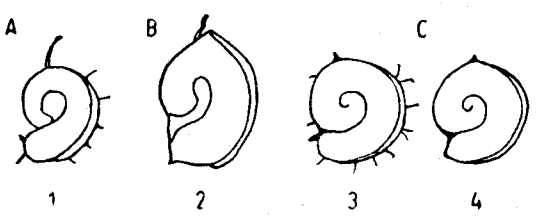

Fig. 20. Various types of fruit-stone structure in the genus *Potamogeton:* A. Embryo strongly coiled, central depression (*1. P. cristatus* Regal et Maack, according to Miki 1961); B. Embryo less strongly coiled, lateral depression (*2. P. oxyphyllus* Miq., according to Miki 1961). C. Embryo convoluted spirally, absence of depression (*3. P. spirillus Tuckern,* the Herbarium of the Institute of Botany of the Polish Academy of Sciençes, Kraków; *4. P. spirilloides* Miki, according to Miki 1961).

Ryc. 20. Różne typy budowy pestek u rodzaju *Potamogeton:* A. Zarodek silnie zwinięty, zagłębienie centralne (*1. P. cristatus* Regel et Maack, według Miki'ego 1961), B. Zarodek mniej zwinięty, zagłębienie boczne (*2. P. oxyphyllus* Miq., według Miki'ego 1961), C. Zarodek spiralnie zwinięty, brak zagłębienia (*3. P. spirillus* Tuckern, Zielnik Instytutu Botaniki PAN, Kraków; *4. P. spirilloides* Miki, według Miki'ego 1961)

species: *P. spirillus* Tuckern., *P. capillaceus* Poiret., *P. diversifolius* Raf., and *P. bicupulatus* Fernald (M u e n s c h e r 1944).

In the present state of studies it can be assumed that in the Miocene of Poland forms proximate to the East Asiatic species *P. cristatus* were extant. Apart from the species *P. pygmaeus* Chandler confirmed at Pierzchów, the fruit-stones of *P.* cf. *cristatus* Reg. et Maack described by R a n i e c k a - B o b r o w s k a (1959) from the Mio-Pliocene of Konin should also be mentioned. It should, however, be noted that the fruit-stones from Konin are considerably larger than this small fruit species since they are 1·9 — 2·4 mm. long and 1·3 — 2·0 mm. broad [1].

Potamogeton cf. ***heinkei*** Mai

Pl. VI, *12;* Fig. 19, *10*

Locality: Łapczyca 74

Fruit-stone small, almost rounded in shape (1·45 × 1·4 mm.), considerably flattened, with a poorly defined upper beak and a narrow keelless germinal valve. The central depression very marked, the walls of the endocarp thin, with an external layer of cells that have large lumina.

The described fragment is strikingly similar to the species *P. heinkei* recorded by M a i (1960) from the Lower Miocene of Hartau near Żytawa. The fruit-stones of this species are oviform or markedly roundish in shape and, as the author points out, they differ from the other small fruit Tertiary species (*P. wiesaensis* Kirchh. and *P. tenuicarpus* Reid.) in their very small beak and the absence of the keel on the germinal valve. Their anatomical structure reveals a considerable amount of spongy tissue. The contemporary counterpart has not so far been found.

According to M a i, similarly built remains have been described from the Pliocene of Holland (R e i d 1915) as *Potamogeton* sp. 5 and *P.* sp. 10. This suggestion does not seem correct, if only because of the considerably larger dimensions of the above-mentioned remains (2·4 × 1·6 mm. and 1·9 × 1·7 mm.). On the other hand, strikingly small and roundish fruit-stones have been described from the Pliocene of Pont de Gail (R e i d 1923) as *Potamogeton* sp. 5 (l.c. Pl. X, fig. 1).

From the Tertiary floras on the Irtysh in Western Siberia very small roundish fruit-stones have been described by D o r o f e e v (1963a, Ris. 14, *18—22*) under the name of *P. minimus.* Nevertheless, they have a strong and large upper beak somewhat shifted towards the dorsal side, and therefore cannot be compared with the specimens from Łapczyca.

[1] From the Miocene of Western Siberia D o r o f e e v (1963a) has described a fruit-stone of *Potamogeton* sp. 3, pointing to its considerable similarity to *P. pygmaeus.* It is also larger (1·7—1·3 mm) and has a shorter germinal valve.

From the Mio-Pliocene of Konin a very small and round fruit-stone of *Potamogeton* sp. 4 has also been described (Raniecka-Bobrowska 1959, Tabl. XXV, fig. 11). It has a large and deep central depression and a very poorly defined upper beak. The author assumes that the germinal valve had thorns and so suggests some similarity to the North American species *P. spirillus* Tuckern. and *P. capillaceus* Poiret. As has been mentioned above, these two species have fruit-stones spirally coiled and their structure is completely different.

Juncaceae

Juncus sp.

Pl. VI, *13;* Fig. 19, *11*

Locality: Kłaj 53

Seed small (0·65 × 0·3 mm.), somewhat tapering in the basal part and markedly elongated at the apex, slightly asymmetrical. The surface marked with some 20 delicate longitudinal striae among which the transverse walls of cells can be seen. The structure of the seed is very characteristic and typical of the genus *Juncus.*

This genus was described for the first time by Heer (1855, 1859) from the Swiss Oligocene and Miocene where impressions of solitary capsules have been found. According to Kirchheimer (1957), only the remains from Oeningen determined as *Juncus articulatus* Heer (Taf. 147, Fig. 17) belong to this species, the remaining specimens being doubtful. The seeds of *Juncus* were confirmed in Miocene deposits for the first time by Rudolph (1935).

Rushes are plants of wet habitats, widely distributed in the Northern hemisphere. Individual species differ from one another also in the structure of seeds. Apart from shape and size, an important characteristic is the appearance of cells of the testa overlaid in longitudinal bands. Depending on the size of cells, the surface of the seed contains more or fewer such longitudinal bands, and at the same time the number of longitudinal striae (that arise as a result of a more intensive thickening of the two walls in each cell) alters.

In the majority of species the cells of the testa are fairly large and the number of longitudinal ribs slightly exceeds 10. There are, however, several species in which the cells of the testa are smaller and the number of longitudinal ribs larger. It is to this type of seeds that the specimen from Kłaj belongs, as it has on its surface some 20 longitudinal ribs and markedly rectangular cells.

The seed from Kłaj shows comparatively the closest resemblance to the seeds of *J. bulbosus* L. (= *J. supinus* Moench.) which grows frequently on wet ground or even in small pools. However, the seeds of this species are somewhat smaller than those of the fossil specimen.

Occurrences of the genus *Juncus* in the Miocene of Southern Poland: the "Gdów Bay", Skopanie, Domański Wierch.

Cyperaceae

The remains of *Cyperaceae* are amply represented in the deposits of the „Gdów Bay". Apart from the fruits of the genera *Carex, Scirpus, Schoenoplectus, Heleocharis* and probably *Cyperus,* stems and rootstocks as well as roots of plants from the family *Cyperaceae* have been found, too. The considerable share of the remains of this family in the other Miocene floras of Southern Poland (Stare Gliwice, Zakrzów, Skopanie, Chyżne, Domański Wierch) as well, should be stressed.

Carex aff. *rostrata* Stokes

Pl. VII, 7; Fig. 21, 1

Locality: Suchoraba 22

Fruit elongated (2·1 × 1·1 mm.) broadest at its half-length, somewhat asymmetrical, triangular. The basal part rather broad, the upper part tapering to a well-fixed neck, almost totally broken off. Surface reticulate, composed of large polygonal cells forming longitudinal rows.

Similarly built fruits derived from Mio-Pliocene and Miocene deposits have been described as *Carex* aff. (or cf.) *rostrata* Stokes by Raniecka-Bobrowska (1959) and Dorofeev (1963a).

Carex rostrata, a species commonly occurring today on wet and swampy grounds of the entire Holarctic has fruits rather variable in shape although forms that are markedly stocky and broadest in the upper part predominate. Of this „typical" shape are the fruits from the Pliocene and Pleistocene of Mizerna (Szafer 1954), and from various Quaternary deposits (e.g. Kräusel 1937; Dorofeev 1963c).

In the contemporary specimens of this species there also occasionally occur more elongate fruits with the base tapering slightly to a small leg (Mackenzie, Creutzburg 1940; Nötzold 1962 and comparative collections of the Institute of Botany of the Polish Academy of Sciences in Kraków). This type of fruit is fairly closely resembled by the Miocene remains from Konin, Kirevskoye on the Ob, and from the „Gdów Bay".

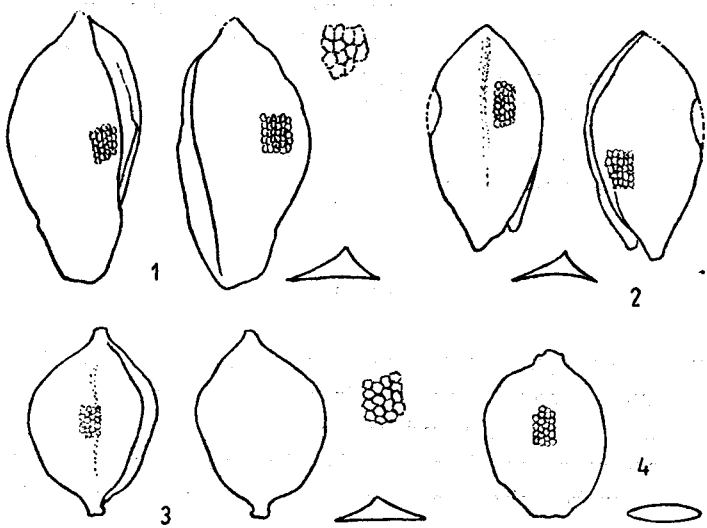

Fig. 21. Fruits of *Carex* sp. div., × 16: *1. Carex* aff. *rostrata* Stokes (Suchoraba 22); *2. Carex* sp. 1. (Kłaj 39); *3. Carex* sp. 2. (Łapczyca 74); *4. Carex* sp. 3 (Siedlec 64).

Ryc. 21. Orzeszki *Carex* sp. div. × 16: *1. Carex* aff. *rostrata* Stokes (Suchoraba 22); *2. Carex* sp. 1. (Kłaj 39); *3. Carex* sp. 2. (Łapczyca 74); *4. Carex* sp. 3 (Siedlec 64)

Carex sp. 1

Fig. 21, *2*

Locality: Kłaj 39

Fruit triangular, symmetrically elongated (1·8 × 0·95 mm.), broadest somewhat above its half-length, tapering uniformly in the basal and apical parts. Neck of pistil broken off at the base, surface covered with large polygonal cells.

So built, yet different in size, fruits occur in numerous species of sedges. Fruits not exceeding 2 mm. in length are encountered in, among others, the North American species *C. Breweri* Boott. and *C. conspecta* Mack. (Mackenzie and Creutzburg 1940, Pl. 5 and 346) and the holarctic species *C. acutiformis Ehrh. (= C. paludosa* Good.). This latter species, common with us on wet grasslands and on the banks of inland waters, has been described from Pleistocene deposits (Kräusel 1937) and from the border of the Pliocene (Reid 1920b).

Carex sp. 2

Pl. VII, *8*; Fig. 21, *3*

Locality: Łapczyca 74

Fruit small (1·3×1·0 mm.) triangular, strongly flattened. The maximum breadth is at half its length; in the upper and lower parts it is fairly considerably narrowed, the base being markedly elongated. The surface reveals large and regular hexagonal cells arranged in uniform rows. The fruit is of characteristic appearance because of its shape, the delicate neck of the pistil and, above all, the presence of a small elongated „pseudo-leg" in the basal part.

The considerably elongated „pseudo-leg" occurs comparatively rarely in fruits of the genus *Carex*. Thus, for instance, out of 533 species of North American sedges (Mackenzie, Creutzburg 1940), less than 20 have fruits of this type. Fruits very small and in shape similar to the specimen from Łapczyca are encountered in, among others, the species *C. Haleana* Olney (wet meadows, coastal regions), *C. epapillosa* Mack. (mountain grasslands), and *C. montanensis* L. H. Bailey (meadows near streams). Similar forms could surely be found also among sedges coming from other continents.

In the palaeobotanical literature I have not come across descriptions of this type of fruits of the genus *Carex*. The nuts of *C.* sp. sect. *Frigidae* reported from Krościenko (Szafer 1946, Tabl. XV, fig. 28) and from the Miocene of Western Siberia (Dorofeev 1963a, Tabl. XV, *10*) also have long „legs", though they are considerably larger and in shape more elongate than the specimen from Łapczyca.

Carex sp. 3

Fig. 21, *4*

Locality: Siedlec 64

Fruit small (1·1 × 0·9 mm.), egg-shaped, flat, lenticular in section. The base of the fruit and the base of the neck of the pistil are broad. Surface reticular composed of large hexagonal cells.

Flat fruits occur in sedges with the same frequency as triangular ones, but in the main they have dimensions somewhat larger than our fossil one. To illustrate this, it may be mentioned that out of 533 North American species about 250, that is almost half, have flat nuts. Small fruits whose length varies between 1·0 — 1·5 mm., occur there in about 20 species (Mackenzie, Creutzburg 1940).

Flat fruits, somewhat larger than those of the specimen from Siedlec (1·0 — 1·7 mm. in length) and having, in addition, a somewhat more delicate base of the pistil, have been described by Dorofeev (1963a) from the Miocene of Western Siberia under the name of *Carex* sect. *Vignea*.

cf. *Cyperus* sp.

Pl. VI, *14*; Fig. 19, *12*

Locality: Kłaj 39

Fruit triangular, elongated (1·6 × 0·7 mm.), almost uniformly narrow, tapering evently in the basal and apical parts. The apex has a short blunt beak, about 0·1 mm. long. Surface delicately pitted, composed of small cells arranged in longitudinal rows.

Similarly built fruits occur in some species of *Cyperus* although the majority of species of this genus have very small fruits, not exceeding 1 mm. in length.

Among others, the East Asiatic species *C. rotundus* L., *C. truncatus* Turcz., *C. umbellatus* Benth. [1] and also the species occurring in the Eurasian region *C. glomeratus* L. and *C. longus* L. (= *C. fastigiatus* Willd. = *C. tenuiflorus* Willd. = *C. Heldreichianus* Boiss). have comparatively large and elongated fruits.

The fossil fruit from Kłaj is very similar to the species *C. rotundus* L. and *C. longus* L. This latter, however, has fruits that are somewhat more elongated at the base (Kowal 1958).

The fruits of the genus *Cyperus* — undetermined specifically with the exception of *C. glomeratus* — are known, above all, from the Pliocene floras of Eurasia thanks to the works of Dorofeev (1956, 1957ab, 1961, 1962, 1963a). The same author has also reported the fruits of *C.* cf. *glomeratus* and *Cyperus* sp. (0·7 mm. long) from the Miocene of the Rostov area. It should be added that the genus *Cyperus* has so far been known from Miocene and older floras mainly on the basis of leaves and rootstocks (Heer 1855, 1859). The three small fruits lying by the side of leaves of *Cyperus Chavannessi* Heer and *Cyperites margarum* Heer presented under the same names do not show characteristics typical of the genus *Cyperus* and do not really admit of identification, to which fact attention has been drawn by Kirchheimer (1957).

[1] Comparative material came from Japan (herbarial collections).

Scirpus cf. *silvaticus* L.

Pl. VII, *1*; Fig. 22, *1*

Locality: Pierzchów 26

Small and very delicate triangular fruit (1·0 × 0·6 mm.), oviform, somewhat narrowed at the base and apex. In the apical part a short, bluntly cut off beak is visible; the basal part is torn. Sculpture minutely and delicately pitted.

This fruit shows the morphological characteristics of the genus *Scirpus* sensu stricto (K o w a l 1958; K o w a l and M a r e k 1961). Probably the same applies to the anatomical characteristics because in spite of its being impossible, on account of the poor state of preservation of the fragment, to carry out anatomical section, it can nevertheless be seen that the wall of the fruit is very thin. According to M a r e k (1958), it consists, in the genus *Scirpus*, of only 2—4 layers of small sclerenchymatic cells similarly to the genus *Cyperus*. The absence of traces of bristles in the fossil specimen is understandable since in all the species of the genus *Scirpus* they are very fragile.

The fossil fruit corresponds quite well in shape and size to our species of bulrushes *S. silvaticus* L. and *S. radicans* Schkukr., in particular to the

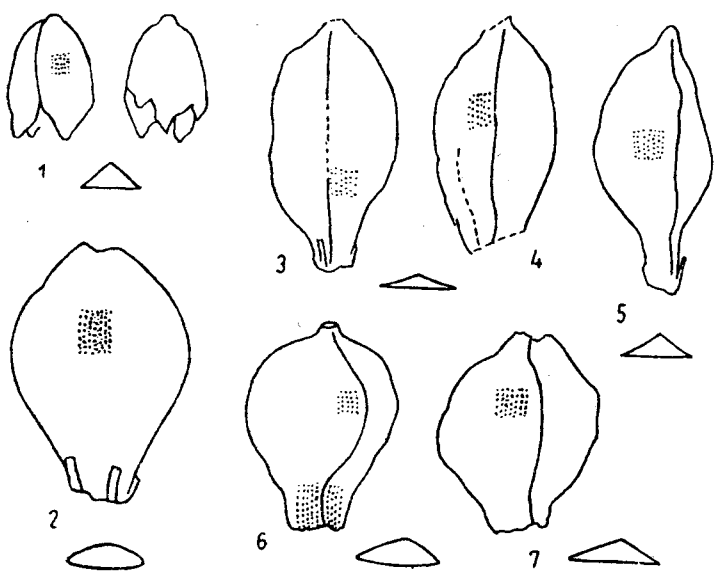

Fig. 22. Fruits of the genus *Scirpus* sensu lato, × 16: *1. Scirpus* cf. *silvaticus* L. (Pierzchów 26); *2. Schoenoplectus* aff. *Tabernaemontani* (Gmel.) Palla (Suchoraba 22); *3—5. Schoenoplectus* sp. 1 (Siedlec 63); *6, 7. Schoenoplectus* sp. 2. (Siedlec 63).

Ryc. 22. Owocki rodzaju *Scirpus* sensu lato, × 16: *1. Scirpus* cf. *silvaticus* L. (Pierzchów 26); *2. Schoenoplectus* aff. *Tabernaemontani* (Gmel.) Palla (Suchoraba 22); *3—5. Schoenoplectus* sp. 1 (Siedlec 63); *6, 7. Schoenoplectus* sp. 2. (Siedlec 63)

former. The fruits of this species in herbarial collections are frequently completely devoid of the easily broken bristles.

Small fruits of the genus *Scirpus*, not exceeding 1 mm. in length, have been found many times in Tertiary floras especially by Nikitin and Dorofeev[1]. The species *S. silvaticus* L. has been reported from the Pliocene of the Kama and of Byelorussia (Dorofeev 1956, 1960) and related fruits from the Miocene of Western Siberia have been described by Dorofeev (1963a) as *S. nagorskyi* Dorof.

The fossil fruit from Pierzchów shows considerable similarity to *S. nagorskyi* Dorof. whose smooth fruits are 0·9 — 1·0 mm. long and 0·3 — 0·5 mm. broad.

Schoenoplectus aff. ***Tabernaemontani*** (Gmel.) Palla

Pl. VII, *2;* Fig. 22, *2*

Locality: Suchoraba 22

Fruit 2·0 mm. long and 1·4 mm. broad, flattened, broadly oviform. The base of the fruit broad, tapering cuneately, bluntly cut off with remains of preserved bristles. The apex markedly tapering, but the beak damaged. The fruit has 2 rounded edges; in section it has the shape of a unilaterally convex lens since one lateral side of the fruit is entirely flat and the other convex. Sculpture pronounced and in the form of a fine reticule with isometric meshes.

The dimensions of the fruit and considerable thickness of the walls of the pericarp which can be ascertained without resorting to anatomical section, indicate the genus *Schoenoplectus* (Kowal 1958; Marek 1958). The specimen from Suchoraba corresponds in size and shape to the species *Sch. triqueter* (L.) Palla (= *Scirpus triqueter* L.) from which, however, it differs in external sculpture. On the other hand, this specimen shows considerable similarity to the fruits of *Sch. Tabernaemontani* (Gmel.) Palla (= *Scirpus Tabernaemontani* Gmel.) whose length is 1·9 — 2·1 mm. and breadth 1·4—1·6 mm., and which have the apical part prominently tapering and external sculpture finely reticulate (Kowal 1958). The difference consists in the fact that contemporary nuts are usually narrower at the base than the fossil specimen.

Scirpus cf. *Tabernaemontani* Gmel. has been reported from the Dutch Pliocene (Reid 1915) and from the Miocene of Stare Gliwice (Szafer 1961). These remains, however, cannot be ascribed to this species because

[1] This type of fruit with beautifully preserved bristles have been found in the Oligocene flora of Rott in Siebengebirge and described as *Cyperaceae* (Weyland 1941, Tabl. XVI, fig. 3).

the fruit from Swalmen (Pl. II, fig. 27) was — judging only from the figure — triangular, and the fruits from Stare Gliwice (Tabl. XXIV, figs. 11—14) are smaller (1·5 — 1·8 × 0·9 — 1·0 mm.), markedly triangular, and most probably belong to the species common in that flora, *S. pliocaenicus* Szafer.

Schoenoplectus sp. 1

Pl. VII, *3, 4;* Fig. 22, *3—5*

Locality: Siedlec 63

Three elongate fruits (2·0×1·0 mm.), oblong-oviform in shape, triangular, at the apex slightly rounded and at the base markedly elongated with preserved remains of bristles. Lateral walls flat and thick. Surface sculpture very finely pitted.

These fruits are similar to *Scirpus tertiarius* described by D o r o f e e v (1963a) from the Miocene floras of Western Siberia. Fruits of this species are not very large (1·8 — 2·1 × 1·0 — 1·1 mm.) and are uniformly elongated. According to D o r o f e e v, the contemporary North American species *S. nevadensis* Wats. and *S. carinatus* Gray have, indeed, fruits approximate in shape yet larger in size. The species *S. pliocaenicus* described from the Pliocene of Krościenko (S z a f e r 1947) has fruits somewhat different from *S. tertiarius*. They are larger (2·1 — 2·6 × 1·1 — 1·5 mm.), comparatively broader clubbed in shape and equilaterally triangular in section (D o r o f e e v 1963a, p. 121).

The lack of original specimens of *S. tertiarius* Dorof. and the poor state of preservation of the remains from the „Gdów Bay" is the reason for my not describing these latter under a specific name.

It should be added that both the dimensions of the fruits of *Scirpus tertiarius* Dorof., and the considerable thickness of their walls — of which mention is made by the author — indicate that this fossil species belongs to the genus *Schoenoplectus*.

Schoenoplectus sp. 2

Pl. VII, *5, 6;* Fig. 22, *6, 7*

Locality: Siedlec 63

The fruits broadly oviform in shape, considerably flattened but triangular in section and 1·6 × 1·25 mm. in size. The apical part rounded with a short and blunt beak (Fig. 22, *6*) or somewhat pointed (Fig. 22, 7), the base broad and bluntly cut off. Surface sculpture finely pitted.

Fruits similar in size and shape have been described by Dorofeev (1963a) from the Miocene floras of Western Siberia under the name of *Scirpus melanospermus* C. A. M. However, they have on their surface transverse undulate creases (l. c. Ris. 18, *19*). According to Dorofeev, similarly built fruits with a smooth surface occur in the species *Scirpus bucharicus* Roshev.

Without appropriate comparative material it was impossible to estimate to what extent the remains from Siedlec correspond to this species occurring in Central and Eastern Asia. From description and figures given in Russian floras (Flora SSSR, t. III, 1935; Flora Tadžikskoj SSR, t. II, 1963) it follows, however, that the fruits of *Schoenoplectus bucharicus* (Roshev) Grossh. have conspicuous transverse creases.

Heleocharis sp.

Pl. VII, *9*; Fig. 23, 7

Locality: Cichawa 25

Only a part of the triangular fruit has been preserved as one of its lateral walls is destroyed. The length of the fruit without the beak is 1·7 mm., the breadth about 1·0 mm., and the shape oviform-elongate. At the apex of the fruit is located a beak strongly narrowed in its upper part and decisively separated from the lateral walls of the fruit which are rounded at the top. The base of the fruit is cuneate and bluntly ended. Lateral edges are distinct, bristles lacking. Sculpture of the fruit finely pitted, in addition parallel convexities and grooves running through the long axis of the lateral walls are manifested. The internal side of these walls is finely striated transversely.

Fruits with such a characteristically built apical part are encountered in *Heleocharis pauciflora* (Lightf.) Link. (= *Scirpus pauciflorus* Lightf.), occurring today in Europe and Asia on the shores of inland waters and on peaty grassland.

The specimen from Cichawa represents, indeed, a form very closely related to *H. pauciflora* but is not identical with it. The fossil fruit is more slender, broadest at its half-length (and not above it) and has a shorter beak (cf. Kowal 1958, Tabl. I, fig. 10).

The oldest fruits of the genus *Heleocharis* as yet known come from the Pliocene floras of Eurasia (Szafer 1954; Nikitin 1957; Dorofeev 1957b, 1962; Miki 1961; Mai, Majewski, Unger 1963) from which have been described the species with a small cap set on the apex, namely, *H. palustris* (L.) R. et Sch., *H. ovata* (Roth.) R. et Sch., *Heleocharis* sp. and *H.* (*Eleocharis*) *microstylosa* Mai.

Gramineae gen. div.

Pl. VII, *10, 11;* Fig. 23, *1—6*

Localities: Kłaj 53, 55; Siedlec 63

In numerous samples small elongate remains, strongly flattened, at one end more or less rounded and at the other distinctly pointed, were found. For the most part these specimens are so damaged that apart from size and shape it is impossible to observe in them any other details of morphological structure. Probably they are all fruits of various kinds of grasses.

The best preserved specimen is 1·5 mm. long and 0·6 mm. broad and comes from the Kłaj 55 sample (Pl. VII, *10*; Fig. 23, *2*). The place where a large embryo is located is well marked. The wall of the fruit is split and unfolded in its lower part and the resulting recess is filled with silt. The fragment is transparent and on the surface traces of elongated cells are distinguishable. A fruit of similar type is represented by the specimen shown in Fig. 23, *1* with dimensions 1·7 × 0·7 mm.

Four relatively well-preserved fruits are somewhat smaller (1·1 — 1·4 × × 0·4 — 0·6 mm.) and have a not very large embryo under which the silted up depression is discernible when the wall of the fruit is ruptured (Fig. 23, *3, 4*). Sometimes this embryo is narrow, situated laterally, and somewhat protruding at the base (Fig. 23, *5* and probably *6* but this lateral determination is not certain because of poorly defined morphological characteristics).

Small fruits with a small, obliquely located and protruding embryo occur in various genera of grasses such as, for instance, *Holcus, Deschampsia, Agrostis, Calamagrostis*, and many others.

It should be stressed that pollen grains of *Gramineae* have been confirmed in palynological analysis of the Suchoraba sample and that in a few other samples stems of grasses were found.

From the leafy floras of Eurasia stems and leaves of grasses have frequently been described, but fruits relatively rarely. The species of the genera *Panicum* and *Poacites* differentiated on the basis of vegetative parts and fruits by H e e r in the Swiss Tertiary (1855, Taf. 25) are not, according to K i r c h h e i m e r, sufficiently documented botanically. The remains from the Upper Miocene flora in Randecker Maar near Kirchheim, presented as the fruits of *Panicum minutiflorum* Sap. (R ü f f l e 1963, Taf. II, Fig. 1—4; Taf. XVII, Fig. 3—5) show neither the morphological nor the anatomical features of the genus *Panicum* (cf. N e t o l i t z k y 1915). Their external structure corresponds with the fruits of the genus *Ruppia* on account of their asymmetrical shape, the presence of a germinal lid (which comes off on drying as in the genus *Potamogeton*) and of the fruits being set on a very long and thin stalk. Also the picture of anato-

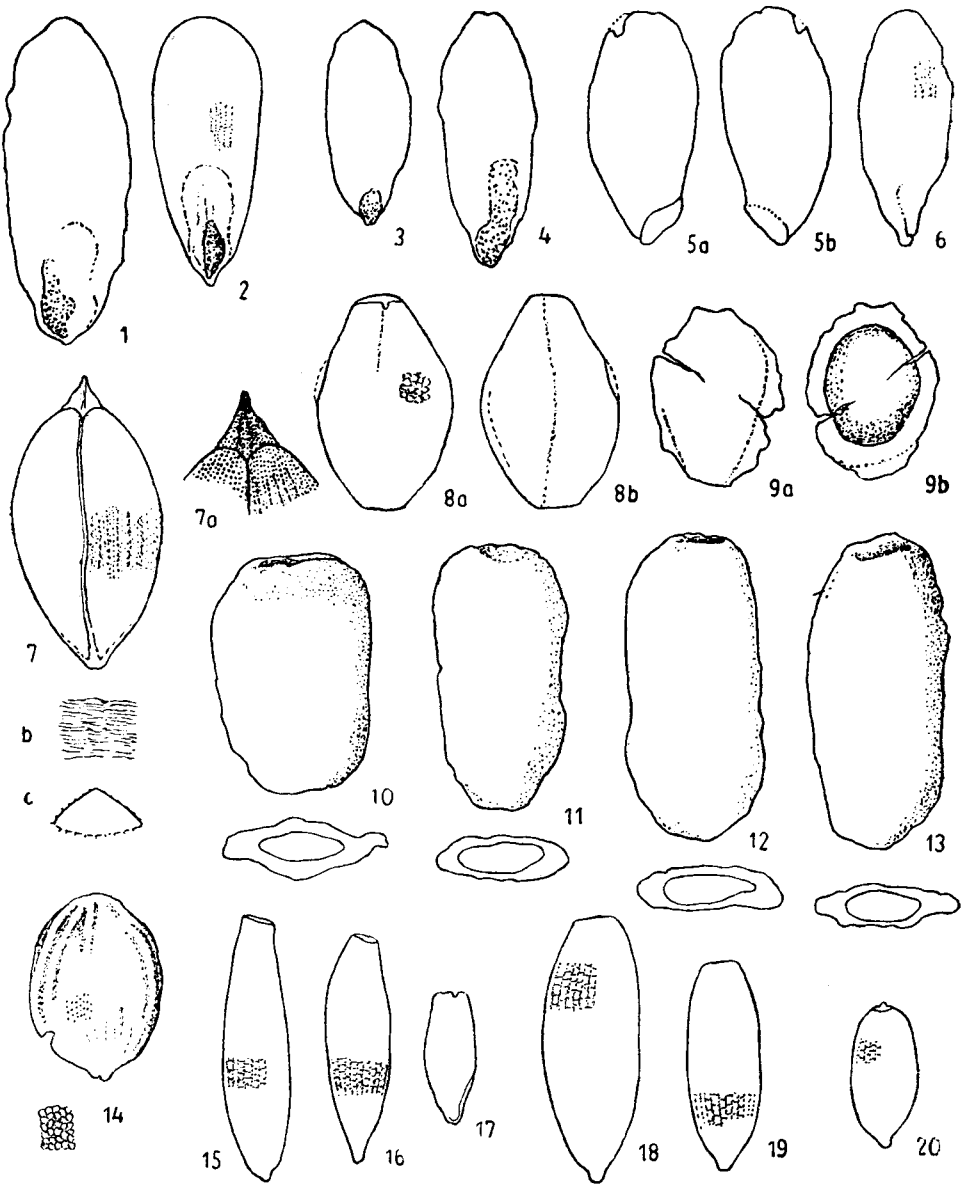

Fig. 23. *1—6. Gramineae* gen. div., fruits, × 25 (Kłaj 53, *1, 3, 5;* Kłaj 55, *2;* Siedlec 63, *4, 6*); 7. *Heleocharis* sp., fruit, × 20 (Cichawa 25): 7 *a* — apex of fruit strongly magnified, *b* — sculpture of internal wall of fruit strongly magnified, *c* — scheme of cross-section; *8, 9. Sparganium* cf. *camenzianum* Kirchh., endocarps, × 25 (Suchoraba 24, 23); *10—13. Aracispermum canaliculatum* Nikit., seeds and cross-sections made at half their length, × 16 (Łapczyca 74); *14. Lemna* sp., seed, × 25 (Książnice 34); *15—17. Typha* cf. *elongata* Dorof., seeds, × 30; (Kłaj 46, 51, 40); *18, 19. T.* aff. *maxima* Dorof., × 30 (Kłaj 46, 49); *20. T.* aff. *pusilla* Dorof., × 30 (Siedlec 63).

Ryc. 23. *1—6. Gramineae* gen. div., ziarniaki, × 25 (Kłaj 53, *1, 3, 5;* Kłaj 55, *2;* Siedlec 63, *4, 6*); 7. *Heleocharis* sp., owocek, × 20 (Cichawa 25): 7 *a* — szczyt owocka

mical structure obtained on maceration (R ü f f l e, l.c. Abb. 10, Taf. XVII, Fig. 4) agrees with the anatomical structure of the endocarp of the genus *Ruppia*.

Lemnaceae

Lemna sp.

Pl. VII, *12;* Fig. 23, *14*

Seed 1·0 × 0·7 mm., much compressed, oval, slightly asymmetrical, rounded at one end, somewhat narrowed at the other, ruptured. Lateral sides ribbed longitudinally. Only 4 ribs, fairly broad and flattened, have been preserved but there must have been at least 7 of them. Between the ribs are located narrow and not very deep grooves. The whole surface of the seed is covered with tiny cells, roundish in shape and arranged in longitudinal rows.

Seeds so built are encountered in the genus *Lemna* although certain characteristic features of structure such as, for example, the lateral suture or operculum are not discernible in the fossil specimen. For identification I have made use of Pleistocene materials in the Palaeobotanical Museum of the Institute of Botany, Polish Academy of Sciences, in Kraków.

The genus *Lemna* numbers over 20 species living both in subtropical and tropical zones and in temperate regions. Some species have a cosmopolitan distribution; not all of them flower and fructify today, this having not been satisfactorily explained as yet (H i l l m a n 1961).

In the fossil state *Lemnaceae* are known from the Cretaceous (H i l l m a n l. c.) and the genus *Lemna* from the Older Tertiary onwards. The seeds of *Lemna trisulca* have been described by N i k i t i n (1957) from the Pliocene of the Voronesh district, and the seeds of *L. tertiaria* n. sp. by D o r o f e e v (1963a) from the Oligocene and Miocene of Western Siberia. These latter have the dimensions 0·8 —0·9 × 0·5 — 0·8 mm., and 6—10 ribs on each lateral side. According to D o r o f e e v, they have a similarity to the contemporary species *L. trisulca* L., but at the same time also to some seeds of *L. minor* L.

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silniej powiększony, b — skulptura wewnętrznej ściany owocka silnie powiększona, c — schemat przekroju poprzecznego; *8, 9. Sparganium* cf. *camenzianum* Kirchh., endokarpy, × 25 (Suchoraba 24, 23); *10—13. Aracispermum canaliculatum* Nikit., nasiona oraz przekroje poprzeczne wykonane w połowie ich długości, × 16 (Łapczyca 74); *14. Lemna* sp., nasienie, × 25 (Książnice 34); *15—17. Typha* cf. *elongata* Dorof., nasiona, ×30 (Kłaj 46, 51, 40); *18, 19. T.* aff. *maxima* Dorof., × 30 (Kłaj 46, 49); *20. T.* aff. *pusilla* Dorof., × 30 (Siedlec 63)

Araceae

Aracispermum canaliculatum Nikitin

Fig. 23, *10—13*

Locality: Łapczyca 74

There were found 4 cylindrical remains, greatly compressed, 2·0 — 2·5 mm. long and 1·1 — 1·3 mm. broad, with a shallow depression in the apical part which is sometimes slightly expanded (Fig. 23, *10*). In the lower part the remains are usually somewhat narrowed and asymmetrical. The surface is uneven, abraded by sand grains, in spite of which the microgranular structure is discernible on it with here and there slight longitudinal folds and characteristic pitting. In cross-section a black and shining thick wall is visible, in some places thinned. The internal aperture, which is oval, as a result of compression, is filled up with a homogeneous dark-grey substance, most probably of mineral origin.

At first sight these remains are reminiscent of the fruits of the genus *Hippuris*, though two of them are somewhat longer. The fruits of the contemporary species *H. vulgaris* do not exceed 2·0 mm. in length. The Pleistocene specimens of these species reach a length of 2·3 mm. (Birkenmajer, Środoń 1960, and material from Imbramowice which is being studied in the Institute of Botany of the Polish Academy of Sciences). In the fossil state the fruits of *Hippuris* are usually preserved in such a way that the delicate pericarp is damaged and the lignified mesocarp, built from relatively large cells, remains. The mesocarps are cylindrical in shape with a fairly smooth surface on which cells arranged in longitudinal rows can be seen distinctly. Although material from the „Gdów Bay" is very corroded it can, however, be observed that the morphological structure of the remains must have been rather different.

These remains show greater similarity to the seeds of the genus *Aracispermum* from the family *Araceae*, described from the Russian Tertiary by Nikitin and Dorofeev who differentiated between a number of fossil species. The specimens from Łapczyca correspond best in size and shape to the seeds of *A. canaliculatum* Nikit. which are markedly elongated, sometimes slightly broadened in the apical, and frequently asymmetrically narrowed in the lower part. The surface of the seeds is covered with longitudinal folds, occasionally pit-like depressions can be seen. The size of the seeds ranges between 1·7 — 3·7 mm. in length and 0·7 — 1·5 mm. in breadth (Dorofeev 1963a). The fossil specimens which I have received thanks to the kindness of Dr. P. I. Dorofeev are 2·2 — 3·1 mm. long and 1·0 — 1·4 mm. broad.

The morphological structure of the fossil remains from Łapczyca indicates that they belong to the genus *Aracispermum* rather than to the

genus *Hippuris*. To confirm the correctness of this determination the anatomical structure of these remains should, in addition, be examined. However, for fear of destroying the scanty and poorly preserved material no anatomical slides were made. It will be possible to make these only in the course of studies on the morphological and anatomical structures of contemporary and fossil fruits of the genus *Hippuris* at present being carried out by Dr. J. Truchanowiczówna in the Institute of Botany, Polish Academy of Sciences.

It is probable that in the Tortonian of the „Gdów Bay" the seeds of *Aracispermum canaliculatum* were present since beautifully preserved seeds of this plant are to be found in the Miocene flora of Rypin in the Dobrzyń Lake District (Łańcucka-Środoniowa, unpublished material).

Until recently, the seeds of the genus *Aracispermum* were reported only from the Oligocene and Miocene floras of Western Siberia lying on the Irtish, Ob, and Tavda. Lately, two species of this genus from the Tertiary flora of Byelorussia (on the Pripet, the districts of Brest and Homl) have been described by Dorofeev (1960). It is therefore wholly understandable that the seeds of this genus are confirmed in the Miocene floras of Poland as well. They are also to be found in the Tertiary floras of Western Europe. Most probably it is to them that the remains described from the Dutch Pliocene (Reid 1915, Pl. XIV, figs. 24, 25) as the fruits

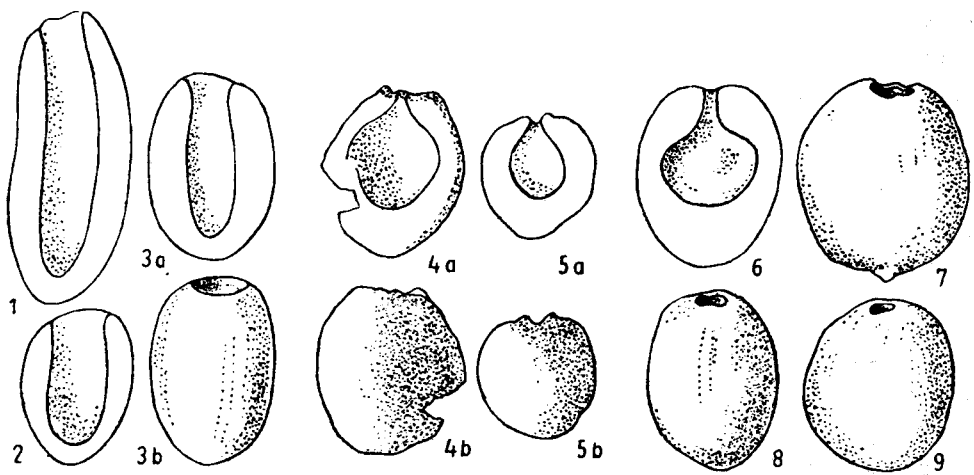

Fig. 24. *1—3. Hippuris vulgaris* L., fruits, × 16 (*1, 2* — fruits from the Interglacial at Imbramowice, *3* — contemporary fruit); *4. Hippuris globosa* Reid, × 12 (Reid 1915); *5. Hippuris* sp. 2, × 12 (Reid 1915); *6—9. Aracispermum ovale* Dorof., × 16 (Dorofeev 1960).

Ryc. 24. *1—3. Hippuris vulgaris* L., owocki, × 16 (*1, 2* — owocki z interglacjału w Imbramowicach, *3* — owocek współczesny); *4. Hippuris globosa* Reid × 12 (Reid 1915); *5. Hippuris* sp. 2., × 12 (Reid 1915); *6—9. Aracispermum ovale* Dorof., × 16 (Dorofeev 1960)

of *Hippuris globosa* n. sp. and *Hippuris* sp. 2 belong. This conclusion may be drawn from the comparison of the morphological structure of fruits of *Hippuris* with the figures of the remains of *Hippuris* from the Dutch Pliocene and of *Aracispermum ovale* Dorof. from the Tertiary of Byelorussia (cf. Fig. 24). Besides the general shape, further evidence is provided by the structure of the internal ventricle, especially its considerable breadth in the middle part and the narrow apical outlet. No doubt, anatomical differences also exist. Already the Reids pointed out that the number of layers of cells that built the „mesocarp" is greater in *H. globosa* than in *H. vulgaris*.

From the comprehensive work of Nikitin (1957) on the Pliocene and Quaternary flora of the Voronesh district, which has only now been made available to us, it follows that this author had long ago advanced such a hypothesis. He linked with the family *Araceae* the remains of *Carpolithes Johnstrupii* Hartz from Tertiary deposits in the Copenhagen area and the remains of *Hippuris globosa* Reid and *Hippuris* sp. 2 from the Pliocene of Holland, calling the latter remains *Aracites Johnstrupii* (= *Aracispermum Johnstrupii*, according to Dorofeev 1963a).

It should be added that as many as three species of *Aracispermum* of similar roundish shape and small size of seed are at present distinguished in Russian floras (Dorofeev 1960, 1963a) viz. *A. globosa* Dorof., *A. Johnstrupii* (Hartz) Nikit.[1] and *A. compressum* Dorof.

The studies of M. E. J. Chandler (1962) on the Eocene of London silts have also revealed the presence of seeds of the genus *Aracispermum* (as understood by Nikitin) which have been determined as *A. arnense* n. sp.

The species *A. canaliculatum*, interesting to us on account of the „Gdów Bay" flora, was distinguished for the first time by Nikitin in 1948. It occurs frequently in the Tertiary floras of Western Siberia (Dorofeev 1955a, 1963a; Kolesnikova 1961; Nikitin and Gorbunov 1962). The length of the seeds reaches even 5 mm, the ventricle has a broad or narrow outlet. (Osnowy Paleontologii 1963, p. 634).

The relationship of the genus *Aracispermum* with contemporary genera has so far not been established. On the other hand, it can be said that the fossil floras in which the seeds of this plant were found, show, in general, a strong relationship with a wet habitat since they are conspicuous for a large share of aquatic, and especially swamp, plants.

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[1] It is interesting to note that the remains of this plant have been found also in Pleistocene deposits on the Don (Nikitin 1957) and in deposits of the Mindel-Riss Interglacial at Żydowszczyzna on the Niemen (Dorofeev 1959). From Interglacial deposits of the same age at Olszewice come a good many of the seeds of *A. Johnstrupii* kept in the Palaeobotanical Museum of the Institute of Botany of the Polish Academy of Sciences in Kraków (materials of Dr. J. Lilpop. det. M. Łańcucka-Środoniowa.

Sparganiaceae

Sparganium cf. *camenzianum* Kirch.

Pl. VII, *13;* Fig. 23, *8, 9*

Locality: Suchoraba 23, 24

One whole endocarp (1·9 × 1·2 mm.) and one fragment (1·5 × 1·1 mm.) were found. The first specimen is strongly compressed, having on both sides traces of longitudinal creases (cracks) and in the narrowed apical part the germinatative aperture. The basal part, also somewhat narrowed, is unfortunately chipped. The maximum breadth of the endocarp is above its half-length. On the external surface the walls of large round sclerenchymatic cells can be seen.

In the second specimen, of which only the obliquely cut off part has been preserved, can be seen the thick wall of the endocarp composed of large sclerenchymatic cells and the oviform internal ventricle. The outlet of this ventricle at the top (the germinatative aperture) is not conspicuous because the remains have been cut off below. On the external surface of the endocarp the walls of large sclerenchymatic cells are visible.

The described remains can with considerable probability be ascribed to the species *Sparganium camenzianum* described by Kirchheimer from the Tertiary of Lusitia (Kirchheimer 1941, 1957). The endocarps of this species vary in size (1·1 — 3·1 × 1·0 — 1·9 mm.) but have the characteristic shape mainly because the maximum breadth is situated above half their length. The endocarps are about 2 mm. long but occasionally one comes across quite small ones as well (Kirchheimer 1957, Taf. 13, Fig. 56).

The two fruits of *S. camenzianum* Kirch. from the Miocene of Stare Gliwice (Szafer 1961) are probably not identical with this species because they are narrower (1·5 × 0·8 and 1·6 × 0·9 mm.) and have the maximum breadth at or below half their length (Bůžek 1963). Somewhat larger endocarps similar in shape to those from Gliwice (1·8 — 2·1 × × 1·0 — 1·5 mm.) have been described by Dorofeev from the Younger Tertiary of Western Siberia as *S. cf. simplex* Huds. (Dorofeev 1963a, Tabl. VII, *1—5*).

Typhaceae

From the samples scrutinized under the binocular microscope come 6 tiny seeds characteristic of the genus *Typha.* They vary both in size (0·6 — 1·2 × 0·2 — 0·4 mm.) and shape. In almost all the specimens the

external testa of the seed is well-preserved and large rectangular cells arranged in longitudinal rows are visible on it.

The genus *Typha* today includes up to 20 species growing in countries with climates ranging from temperate to tropical. Seeds of particular species differ from one another very slightly this having been noted by Dorofeev (1963b) who in his numerous works has given them a good deal of attention and at the moment has at his disposal the richest fossil material.

My investigations of contemporary species (*Typha angustifolia* L. = *T. australis* Schum. et Thonn., *T. latifolia L.*, *T. laxmanni* Lepech. = *T. minima* Hoffm. and *T. Shuttleworthii* Koch. et Sond.) have led to similar conclusions.

In view of the fact that the seeds of contemporary species differ from one another only slightly and that the fossil seeds reveal considerable differences, Dorofeev has advanced the thesis (1963b) that in the Tertiary of Eurasia there must have been more of these species than the number so far distinguished. This opinion is probably correct if one takes into account that the climatic and environmental conditions that prevailed then were very favourable to these plants. Fragments of the leaves of *Typha* are among the most frequently encountered remains in the Neogene flora from Dobrzyń (Kownas 1955) and variously shaped seeds of this genus abound in Rypin (Łańcucka-Środoniowa 1958 and unpublished materials). The seeds coming from the Tortonian of the „Gdów Bay" also differ from one another fairly considerably and it is possible to ascribe them to three different species.

Typha cf. *elongata* Dorof.

Pl. VII, *14—16;* Fig. 23, *15—17*

Locality: Kłaj 40, 46, 51

Seeds narrow, more or less elongate (0·6 — 1·2 × 0·2 — 0·25 mm.), at the base cuneately drawn out into a short small leg, at the apex frequently narrowed and obliquely truncated. The micropylar aperture (the flat disc has not been preserved) 1·5—2 times narrower than the maximum breadth of the seed whose longitudinal axis is sometimes bent upwards.

Seeds of this type occur frequently in the Tertiary floras of Eurasia. Dorofeev as first gave them as *Typha* sp., then suggested similarity to *T. angustifolia* L. (1963a) but most recently has ascribed them to the separate fossil species *T. elongata* (1963 b). This species described from the Oligocene of Kazakhstan occurs also in the Miocene of the Ukraine and Western Siberia.

It should be stressed that our two contemporary species *T. latifolia* L., and *T. angustifolia* L. have seeds of a similar type. According to some authors, the seeds of these species differ from one another because in *T. latifolia* they are somewhat larger and broader (Beijerinck 1947; Nikitin 1957; Mai, Majewski, Unger 1963). The same stand is taken by Dorofeev (1963a) who compared the broader seeds (*T. pliocaenica* Dorofeev) with *T. latifolia* and the narrower ones (*Typha* sp. 2 from Western Siberia) with *T. angustifolia*. The measurements of length and breadth of the seeds coming from 3 stations for each species that have been given by Szafer (1961) seem to confirm this view although differences in breadth are very small. For the average values, these differences amount to 0·02 mm. and for the maximum ones to 0·03 mm.

The observations carried out by me on the material which consisted of 6 samples of each species [1] indicate considerable similarity between seeds of *T. latifolia* L. and *T. angustifolia* L. Failing special studies they are extremely difficult to differentiate owing to the fact that in both species there are variations in size and shape in specimens coming from individual stations, that blot out species differences.

Typha aff. *maxima* Dorof.

Pl. VII, *17, 18;* Fig. 23, *18, 19*

Locality: Kłaj 46, 49

Two seeds 1·2 × 0·4 mm. and 0·9 × 0·3 mm., shaped like uniformly broadened cigar. At the base, cuneately narrowed with a short small leg, at the apex truncated horizontally and about twice as narrow as the maximum breadth of the seed. These specimens correspond with the species *T. maxima* described by Dorofeev (1963b) from the Oligocene of Kazakhstan which has rather large seeds and is isometrically expanded (0·9 — 1·4 × 0·3 — 0·6 mm.).

According to Dorofeev (l. c.), the seeds described from the English Oligocene (Reid, Chandler 1926, Pl. III, figs. 8—11) and the Tertiary of Western Siberia (Dorofeev 1963a) under the name of *T. latissima* A. Br. belong to the same species. This author considers that, as a seed-defining term, the name *T. latissima* A. Br. is not — although he himself employed it at first — appropriate since it was initially applied to impressions of leaves. It refers to remains derived from various ages (from

[1] *Typha latifolia* L.: samples from Poland (Ropczyce, Rzemień, Ludwinów, Suchedniów) and Denmark (Zeeland, Aanosen). *Typha angustifolia* L.: samples from Poland (Tyniec, Chocimierz), Macedonia, Portugal (Lisbon-Botanical Gardens) and Canada (Venice).

the Eocene to the Pliocene) which do not admit of specific discrimination.

The seeds of *T. maxima* Dorof. (= *T. latissima* A. Br.) are known from the Oligocene of Western Europe (England) and from the Oligocene and Miocene of Western Siberia. Large and relatively broad seeds from Dobrzyń (Kownas 1955, Pl. XVII, figs. 11—13), Stare Gliwice (Szafer 1961, Tabl. XXV, figs. 6—8) and Rypin (Łańcucka-Środoniowa, unpublished materials) can probably be ascribed to this species.

Typha pusilla Dorof.

Pl. VII, *19;* Fig. 23, *20*

Locality: Siedlec 63

Seed very small (0·65 × 0·25 mm.) regularly oviform in shape. The small pedicel at the base short and thick and the apical part of the seed rounded with a small micropylar aperture. The flat disc provided with a short thick mucro, is comparatively small, being more than one third of the maximum breadth of the seed.

This seed can be ascribed to the species *T. pusilla* described by Dorofeev (1963b) from the Oligocene of Kazakhstan. The seeds of this species are characterized by small dimensions (0·6—1·0 × 0·2—0·4 mm), fairly considerable breadth at half the length or below it, and by a small micropylar disc.

Similar seeds occur in the Miocene of Rypin in the Dobrzyń Lake District (Łańcucka-Środoniowa, unpublished materials).

Antherites sp. div.

Pl. VII, *20—22;* Fig. 25, *1—11*

Localities: Pierzchów 27, 29, 30; Kłaj 41, 44, 55; Siedlec 62, 63

Samples from the stations at Pierzchów, Kłaj, and Siedlec which have been scrutinized in full under the microscope have furnished, among others, 19 tiny and fragile brown fragments. They are oval in shape, 0·9—1·9 mm long and 0·3—1·0 mm broad. They give the impression of being made up of four elongated parts of which each has a delicate reticulate structure while on the periphery a narrow darker band is distinguishable in which the cells are arranged more regularly. Certain single lying batches of these remains are transparent, light brown in colour and in them the characteristic structure can best be seen. Batches overlying one another are opaque and much darker.

On closer analysis it became apparent that these remains consist of two parts, permanently linked with one another, of which each is longitudinally split and opened to a greater or lesser extent, as a result of which its two sides form one flat surface. In some specimens only one part is opened while the second remains shut.

The remains described above are similar in anatomical and morphological structure to anthers whose ventricles split longitudinally and open in the characteristic manner. In some fossil specimens traces of the connective can be seen.

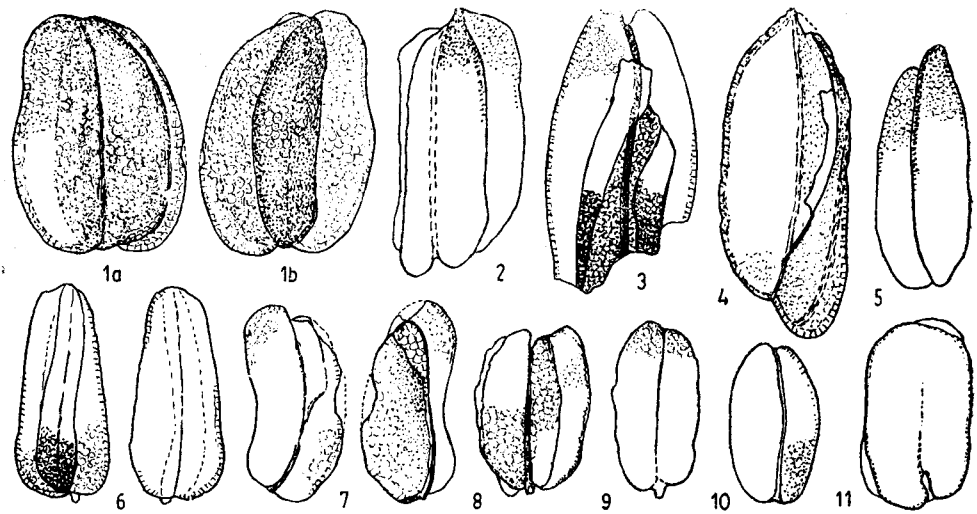

Fig. 25. *1—11. Antherites* sp. div., anthers of various *Angiospermae*, × 25 (Pierzchów 27, *5, 11;* Pierzchów 29, *1, 4, 7, 8;* Kłaj 44, *2, 10;* Kłaj 55, *3, 6, 9*).

Ryc. 25. *1—11. Antherites* sp. div., pylniki różnych roślin okrytozalążkowych, × 25 (Pierzchów 27, *5, 11;* Pierzchów 29, *1, 4, 7, 8;* Kłaj 44, *2, 10;* Kłaj 55, *3, 6, 9*)

The determination of this poorly preserved material has in large measure been made possible by the fact that similar but well-preserved remains occur in the Miocene flora of Sośnica. There, in delicate light brown silts, are to be found impressions of whole male inflorescences with fully visible stamens and anthers which were described as early as 1855 by Goeppert (Taf. XXII, Fig. 1—5) who linked them with the genus *Salix*. Palynological analysis of these inflorescences carried out by Dr. J. Oszast in 1958 revealed whole concentrations of pollen-grains of the genus *Salix*. From the grey silts of Sośnica I have managed to extract numerous smaller and larger anthers, with connective. Their anatomical structure is very well-preserved and concordant with the characteristic spumescent structure of anthers.

In the literature on Tertiary floras one usually comes across mention of anthers found together with flowers as, for instance, in *Podostemonites*

carpatica Szafer (Szafer 1952b), *Halesia kodorica* Kol. (Kolakovskij 1960a), *Burretia instructa* (R. Pot.) Mai (Mai 1961), *Quercus* sp. (Straus 1963b), in flowers of the family *Sapotaceae*, and in those of the type *Nyssa* (Rüffle 1963). It is worth recalling that flowers with anthers have frequently been found in ambers (cf. Czeczott 1961; Gothan, Weyland 1964).

Single anthers found in the Mio-Pliocene flora of Konin have been described as the fruits of the genus *Callitriche* (Raniecka-Bobrowska 1959, Tabl. XIX, figs. 2—12). Judging from the figures supplied, they are remains resembling in size, shape, and manner of preservation the anthers from the „Gdów Bay". Traces of the connective are visible in the specimens represented in figs. 10 and 12. Asymmetrical structure of pouches, conspicuous in almost all the remains from Konin and especially well seen in figs. 9 and 10, is a characteristic feature of anthers. The fruits of the genus *Callitriche* are somewhat different in shape, separate easily and in addition, never split longitudinally, and the walls protecting the relatively large seed are built of thick-walled cells, forming a distinct network (this is not the spumescent structure characteristic of anthers). These cells gradually pass into cells of the transparent wing which surrounds the fruit with a band whose breadth varies according to species.

The single anthers found in the Miocene flora of Wiese have been ascribed to the family *Sapotaceae* (Mai 1964) on the basis of pollen grains isolated by R. Potonié already in 1931.

The extraction of pollen grains from the anthers found in the deposits of the „Gdów Bay" was not possible and the determination of systematic position on the basis of the morphological structure if the anthers would have necessitated special and probably rather unproductive studies. It is, however, possible to state that some specimens from the „Gdów Bay" show considerable similarity to the anthers of the genus *Salix* (Fig. 25, *1*).

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STRESZCZENIE

Rozprawa zawiera wyniki badań nad szczątkami makroskopowymi roślin wydobytymi z piaszczystych i piaszczysto-ilastych osadów tortońskich, występujących na obszarze tzw. Zatoki Gdowskiej. W części ogólnej omówiona została pozycja stratygraficzna 90 przebadanych prób pochodzących z 24 stanowisk (profile geologiczne i próby powierzchniowe), rozrzuconych na obszarze między Wieliczką, Bochnią i Gdowem (por. ryc. 1 i 3). Podano tu również opis materiału kopalnego, wyniki wstępnej analizy palynologicznej (por. str. 12), listę oznaczonych roślin (por. tab. 3), charakterystykę całej flory kopalnej oraz jej porównanie z innymi florami mioceńskimi Polski południowej. W części ogólnej przedstawiona jest także próba podziału tortonu na dwa podpiętra stratygraficzne na podstawie florystycznej (por. ryc. 4).

Cechy charakterystyczne poznanej flory:

1. W jej skład wchodzą zarówno drzewa i krzewy, jak i rośliny zielne i zarodnikowe. Wysoki stosunkowo udział tej ostatniej grupy roślin (około 50%) wiąże się częściowo z dokładnym przeszukaniem materiału pod lupą.
2. Flora ma charakter mieszany, gdyż zawiera składniki rozmaitych zbiorowisk roślinnych (przeważnie leśnych) pochodzących z różnych wyniesień nad poziom morza (por. tab. 4).
3. Ze składu flory wnosić można, iż dominowały siedliska wilgotne, jakkolwiek stwierdzono także rośliny siedlisk dość suchych.
4. Pod względem geograficznym flora reprezentuje przede wszystkim związki z Europą i Azją. W znacznie mniejszym stopniu występują powiązania z obszarem Ameryki Północnej (por. tab. 5).
5. Klimat był prawdopodobnie ciepło umiarkowany, cieplejszy i wilgotniejszy od współczesnego na tym obszarze. Brak zupełny wskaźników klimatu suchego.
6. Z porównania z innymi florami mioceńskimi Polski południowej jak Wieliczka, Swoszowice i Stare Gliwice (por. tab. 6) wynika, że „Zatoka Gdowska" jest równowiekowa z Wieliczką i Swoszowicami, a nieco starsza od flory ze Starych Gliwic. Do gatunków „najstarszych" we florze „Zatoki Gdowskiej" należą: *Eurya stigmosa, Rubus* cf. *microspermus, Epacridicarpum* cf. *mudense, Potamogeton* aff. *pygmaeus, P.* cf. *heinkei* i *Sparganium* cf. *camenzianum.*

Część druga, systematyczna, rozprawy obejmuje opis 85 taksonów wyróżnionych na podstawie szczątków makroskopowych. Oznaczeń gatunkowych jest 44 (52% wszystkich szczątków makroskopowych), dla pozostałych form można było podać tylko rodzaj, sekcję czy rodzinę.

Po raz pierwszy zostały podane z trzeciorzędu Polski następujące gatunki: *Selaginella pliocaenica, Fagus* aff. *orientalis, Liquidambar* aff. *orientalis, Rubus* cf. *microspermus, Eurya stigmosa, Epacridicarpum* cf. *mudense, Potamogeton* aff. *pygmaeus, P.* cf. *heinkei, Juncus* sp., cf. *Cyperus* sp., *Scirpus* cf. *silvaticus, Lemna* sp., *Typha elongata, T. maxima, T. pusilla* oraz mchy oznaczone przez prof. dra B. Szafrana: *Thamnium alopecurum, Echinodium Savicziae, Anomodon longifolius, Heterocladium squarrosulum, Brachythecium velutinum, Cirriphyllum piliferum, Eurhynchium pulchellum* i *E. Swartzii.*

Taxony nowe dla trzeciorzędu Europy: *Broussonetia tertiaria, B. pygmaea,* cf. *Ficus carica,* cf. *Phyllanthus* sp., cf. *Arctostaphylos* sp., *Scrophulariaceae* gen., cf. *Artemisia* sp., *Heleocharis* sp. (aff. *H. pauciflora*) i *Aracispermum canaliculatum.*

W części systematycznej przeprowadzone zostały rozważania natury taksonomicznej nad budową owoców i nasion w następujących rodzajach: *Fagus, Liquidambar, Potamogeton, Actinidia, Ampelopsis, Vitis* i *Aracispermum.*

Instytut Botaniki PAN w Krakowie
Zakład Paleobotaniki

PLATES

Plate I

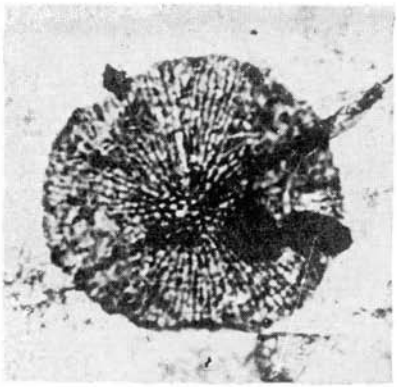
1—5. *Phycopeltis microthyrioides* Kirchh.: *1—3.* Thalli of various sizes, sample Kłaj 41, × 1200; *4.* Fragment of a leaf with thalli of various sizes, sample Kłaj 51, × 40; *5.* Largest specimen, marked with the letter "a" in fig. *4*, × 1200

6—8. cf. *Fungi Imperfecti: 6.* Fragment of epidermis with preserved pycnidia, sample Pierzchów 27, × 10; *7.* Pycnidium from sample Siedlec 63, × 200; *8.* Pycnidium from sample Kłaj 41, × 300

Tablica I

1—5. *Phycopeltis microthyrioides* Kirchh.: *1—3.* Plechy różnej wielkości, próba Kłaj 41, × 1200; *4.* Ułamek liścia z plechami rozmaitej wielkości, próba Kłaj 51, × 40; *5.* Największy okaz, oznaczony literą a na fig. *4.*, × 1200

6—8. cf. *Fungi Imperfecti: 6.* Ułamek skórki z zachowanymi pyknidiami, próba Pierzchów 27, × 10; *7.* Pojedyncze pyknidium z próby Siedlec 63, × 8; *8.* Pyknidium z próby Kłaj 41, × 300



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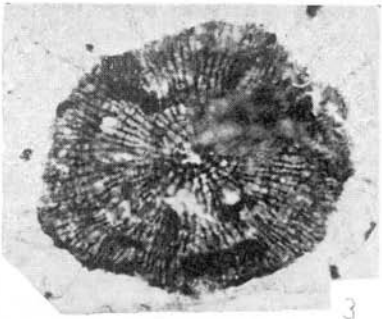

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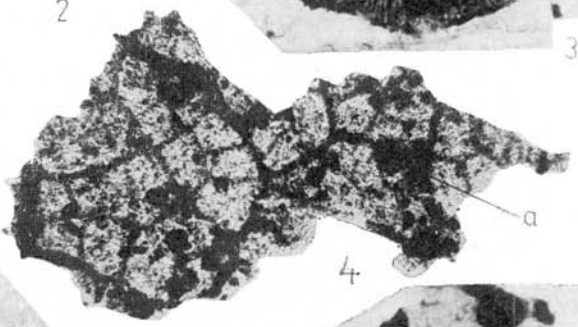

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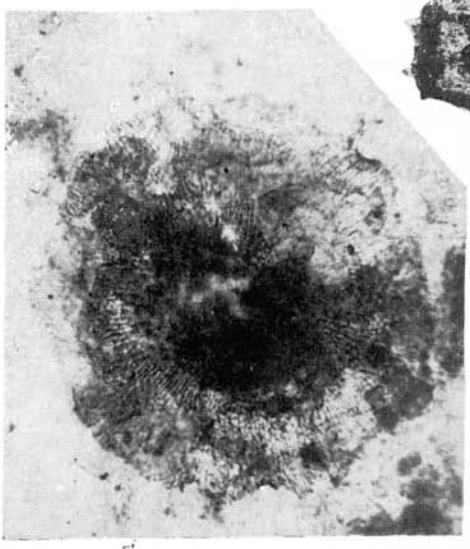

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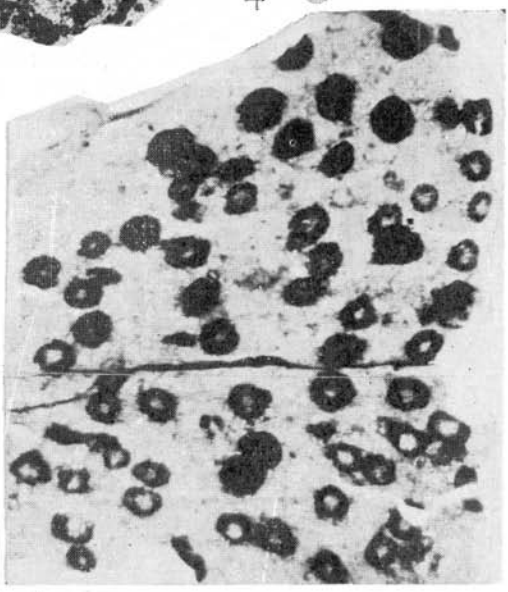

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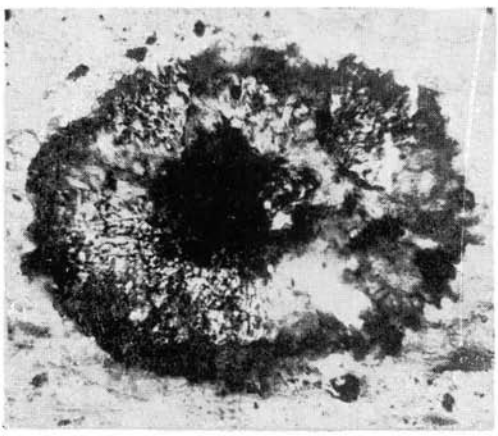

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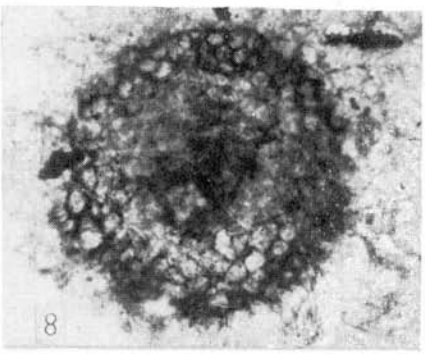

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Plate II

1. *Pyrenomycetes:* fragment of stroma with cavities after fallen out peritheciae, sample Pierzchów 30, × 8
2. *Polyporites* sp.: fragment of hymenium seen from above (*2 a*) and from below (*2 b*), sample Kłaj 35, × 19
3. *Heterocladium squarrosulum* Lindb.: stem with leaves, sample Pierzchów 28, × 100
4. *Thamnium alopecurum* Br. eurp.: a solitary leaf, sample Kłaj 55, × 100
5. *Eurhynchium pulchellum* Dix.: stem with leaves, sample Pierzchów 29, × 100
6. *Anomodon longifolius* Bruck.: stem with leaves, sample Pierzchów 29, × 100
7. *Echinodium Savicziae* A. J. Abr.: apex of a leafy stem, sample Suchoraba 24, × 24
8. *Eurhynchium Swartzii* Curr.: a solitary leaf, sample Pierzchów 28, × 100

9, 10. *Ginkgo adiantoides* (Ung.) Heer: *9* — margin of leaf blade with resin receptacles, sample Pierzchów 26, × 25; *10 a* — fragment of a leaf with preserved epidermis and stomata, sample Kłaj 40, × 20; *10 b* — the same epidermis slightly more magnified

Tablica II

1. *Pyrenomycetes*: odłamek podkładki z zagłębieniami po wypadniętych otoczniach, próba Pierzchów 30, × 8
2. *Polyporites* sp.: odłamek obłoczni widziany z góry (*2 a*) i od dołu (*2 b*), próba Kłaj 35, × 19
3. *Heterocladium squarrosulum* Lindb.: gałązka z liśćmi, próba Pierzchów 28, × 100
4. *Thamnium alopecurum* Br. eurp.: pojedynczy liść, próba Kłaj 55, × 100
5. *Eurhynchium pulchellum* Dix.: gałązka z liśćmi, próba Pierzchów 29, × 100
6. *Anomodon longifolius* Bruck.: gałązka z liśćmi, próba Pierzchów 29, × 100
7. *Echinodium Savicziae* A. J. Abr.: szczyt ulistnionej gałązki, próba Suchoraba 24, × 24
8. *Eurhynchium Swartzii* Curr.: pojedynczy liść, próba Pierzchów 28, × 100

9, 10. *Ginkgo adiantoides* (Ung.) Heer: *9* — brzeg blaszki liściowej ze zbiornikami żywicznymi, próba Pierzchów 26, × 25; *10 a* — ułamek liścia z zachowaną skórką i szparkami, próba Kłaj 40, × 20; *10 b* — ta sama skórka nieco silniej powiększona


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Plate III

1, 2. *Ginkgo adiantoides* (Ung.) Heer: stomata of epidermis (Plate II, *10 b*) from the point marked with arrows, × 300 and × 550 approximately

3. *cf. Taxodium distichum miocaenicum* Heer: fragment of epidermis with stomata arranged at right angles or obliquely to the vein, sample Pierzchów 29, × 75

4, 5. cf. *Cephalotaxus* sp.: fragments of epidermises with stomata, sample Kłaj 44, × 75, 150 and 300

6. *Cephalotaxus Fortunei* Hook. (The Botanical Garden of the Jagiellonian University in Kraków): epidermis with stomata, × 75

Tablica III

1, 2. *Ginkgo adiantoides* (Ung.) Heer: szparki skórki (Tabl. II, *10 b*) z miejsca oznaczonego strzałkami, × 300 i około 550

3. cf. *Taxodium distichum miocaenicum* Heer: ułamek skórki ze szparkami ułożonymi prostopadle lub skośnie do nerwu, próba Pierzchów 29, × 75

4, 5. cf. *Cephalotaxus* sp.: ułamki skórek ze szparkami, próba Kłaj 44, × 75, 150 i 300

6. *Cephalotaxus Fortunei* Hook. (Ogród Botaniczny U. J. w Krakowie): skórka ze szparkami, × 75

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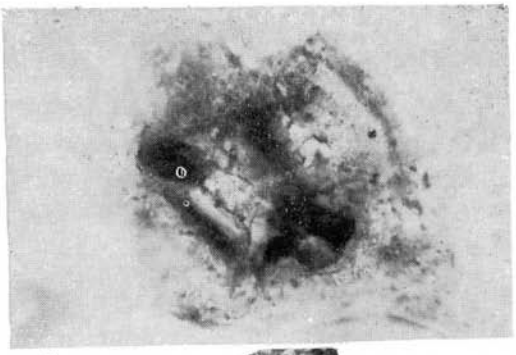

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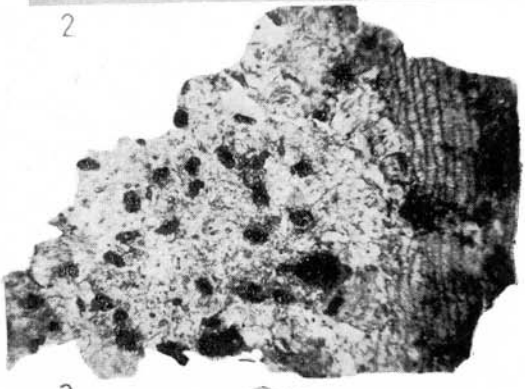

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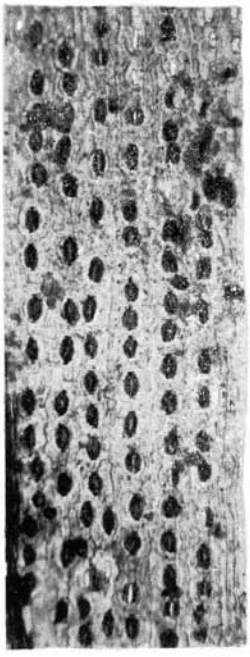

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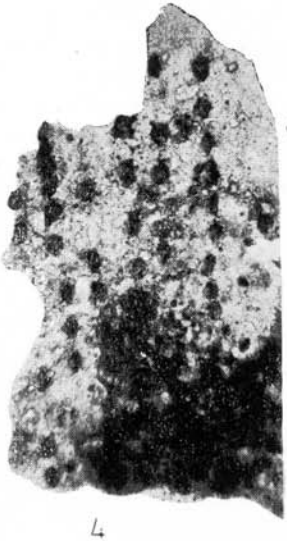

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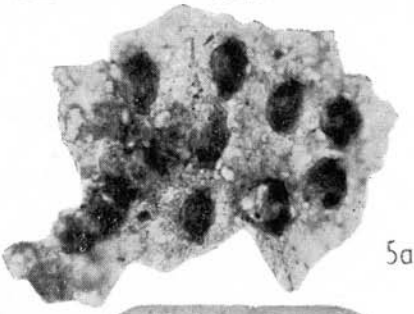

5a

5b

Plate IV

1—4. Pinus sp. div., fragments of epidermis with stomata obtained in maceration of needles, sample Pierzchów 30: *1.* A triangular needle, × 75; *2.* Part of the same epidermis, × 300; *3.* Another specimen of a triangular needle, × 300; *4.* Flat and broad needle, × 200

5—6. Thuja cf. occidentalis L.: individual parts of a shoot from samples Pierzchów 27 and Kłaj 53, × 15 approximately

7. Broussonetia tertiaria Dorof.: endocarp from sample Suchoraba 22, × 5

8. Broussonetia pygmaea Dorof.: endocarp from sample Siedlec 62, × 30

9. Eucommia ulmoides Oliv.: fruit from sample Bodzanów 1, × 2

10, 11. Eucommia sp. from sample Bodzanów 1: *10.* Parts of leaf blade with fibres of gutta-percha, × 90 approximately; *11.* Fibres of gutta-percha from the leaf blade with knobbed thickenings, × 300

Tablica IV

1—4. Pinus sp. div., ułamki skórek ze szparkami uzyskane przy maceracji szpilek, próba Pierzchów 30: *1.* Szpilka trójgraniasta, × 75; *2.* Wycinek z tej samej skórki, × 300; *3.* Inny okaz szpilki trójgraniastej, × 300; *4.* Szpilka płaska i szeroka, × 200

5—6. Thuja cf. occidentalis L.: poszczególne człony pędu z próby Pierzchów 27 i Kłaj 53, × ok. 15

7. Broussonetia tertiaria Dorof.: endokarp z próby Suchoraba 22, × 25

8. Broussonetia pygmaea Dorof.: endokarp z próby Siedlec 62, × 30

9. Eucommia ulmoides Oliv., owoc z próby Bodzanów 1, × 2

10, 11. Eucommia sp. z próby Bodzanów 1: *10.* Część blaszki liściowej z nitkami gutaperki, × ok. 90; *11.* Nitki gutaperki z blaszki liściowej, posiadające buławkowate zgrubienia, × 300


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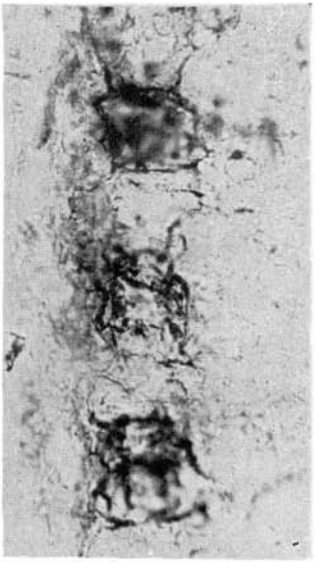
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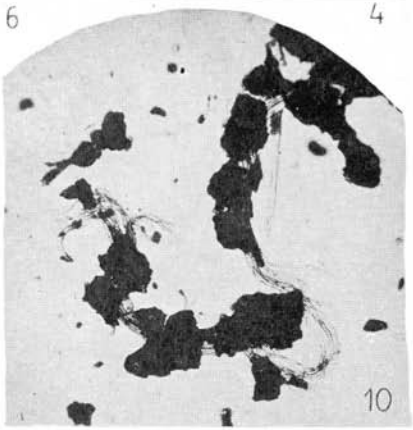
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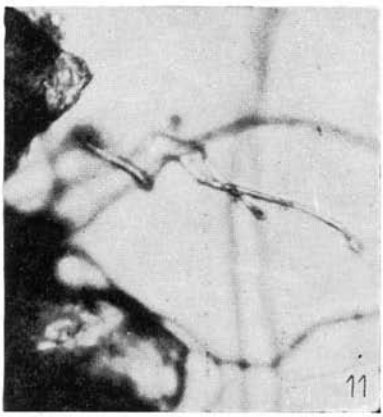
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Plate V

1. *Liquidambar* aff. *orientalis* Miller.: fragment of fructification seen from above (*1 a*) and from below (*1 b*), sample Suchoraba 24, × 12 approximately
2, 3. *Buxus sempervirens* L. foss.: *2.* Fragments of leaf blade from sample Kłaj 49, × 8; *3.* Apical part of a leaf from sample Kłaj 40, × 8
4. *Thalictrum* sp.: fruit from sample Kłaj, × 27
5. *Actinidia faveolata* C.-E.M. Reid: fragment of seed from sample Siedlec 63, × 20
6—9. *Eurya stigmosa* (Ludw.) Mai, seeds from external side, longitudinal section (figs. *6 b, 8*), × 22: *6, 7* — Łapczyca 74; *8* — Kłaj 37; *9* — Wieliczka
10—13. *Rubus* cf. *microspermus* S.-E.M. Reid, endocarps from various samples × 25: *10* and *11* — Książnice 32; *12* — Kłaj 57; *13* — Kłaj 39
14. *Rubus* sp.: thorn from sample Siedlec 63, × 20 approximately

Tablica V

1. *Liquidambar* aff. *orientalis* Miller.: ułamek owocostanu widziany od strony górnej (*1 a*) i dolnej (*1 b*), próba Suchoraba 24, × ok. 12
2, 3. *Buxus sempervirens* L. foss.: *2.* Fragmenty blaszki liściowej z próby Kłaj 49, × 8; *3.* Część szczytowa liścia z próby Kłaj 40, × 8
4. *Thalictrum* sp.: owocek z próby Kłaj 57, × 27
5. *Actinidia faveolata* C.-E.M. Reid: ułamek nasienia z próby Siedlec 63, × 20
6—9. *Eurya stigmosa* (Ludw.) Mai, nasiona od strony zewnętrznej i przekrojone podłużnie (*6 b, 8*), × 22: *6, 7* — Łapczyca 74; *8* — Kłaj 37; *9* — Wieliczka
10—13. *Rubus* cf. *microspermus* C.-E.M. Reid, endokarpy z różnych prób, × 25: *10, 11* — Książnice 32; *12* — Kłaj 57; *13* — Kłaj 39
14. *Rubus* sp.: kolec z próby Siedlec 63, × ok. 20

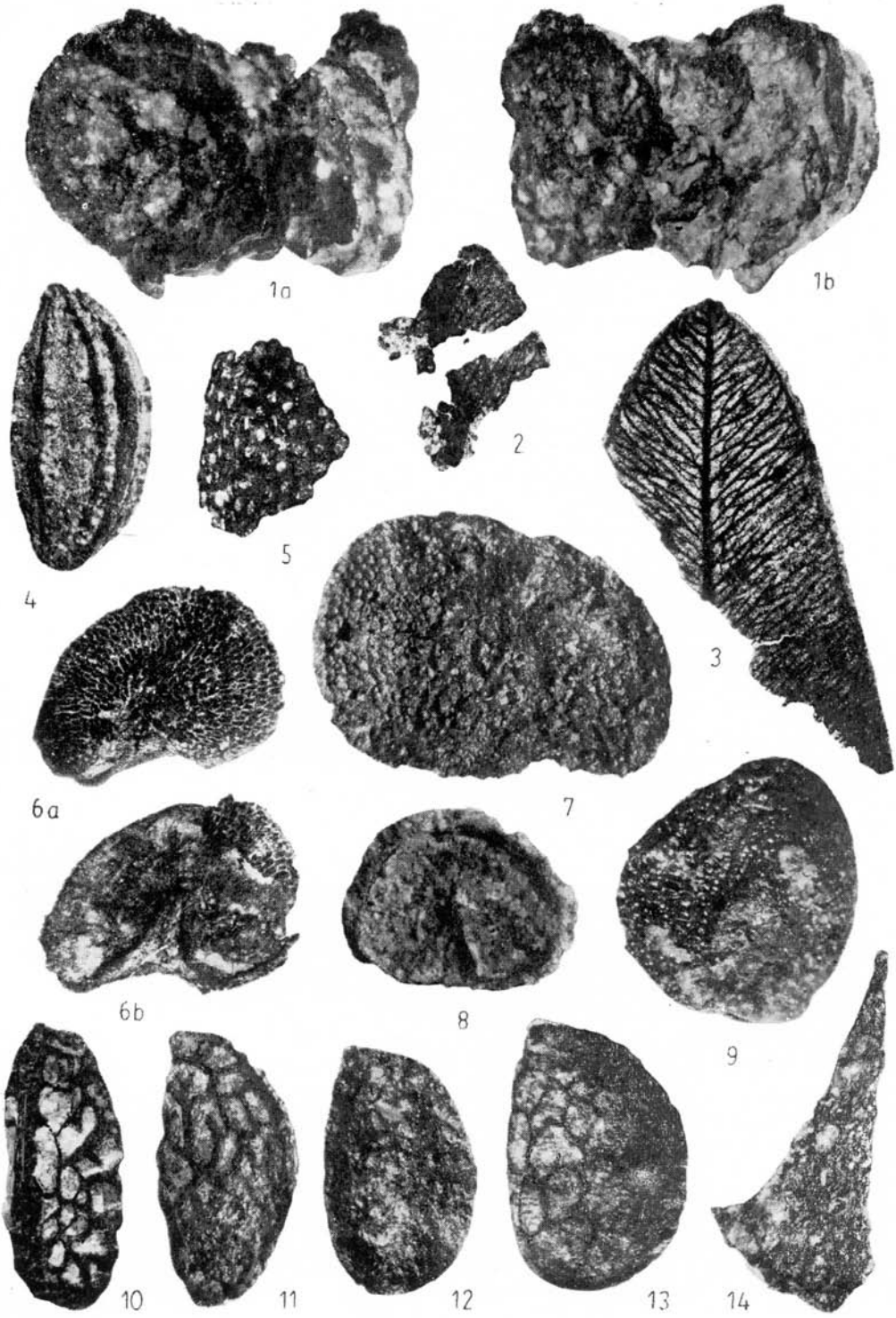
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Plate VI

1. *Acer* sp. 1 (sect. *Palmata* Pax): fruit from sample Siedlec 58, × 12
2. *Acer* sp. 2 (sect. *Spicata* Pax): fruit from sample Pierzchów 30, × 12
3. *Aralia* aff. *hispida* Vent.: endocarp from sample Łapczyca 74 × 12
4. *Cornus* sp.: fruit-stone from sample Suchoraba 24, × 10
5. cf. *Arctostaphylos* sp.: endocarp seen from both sides, sample Suchoraba 20, × 12
6. *Epacridicarpum* cf. *mudense* Chandl.: part of fruit from internal side, sample Gdów 9, × 15 approximately
7. *Scrophulariaceae* gen.: seed from sample Kłaj 44, × 50
8. *Labiatae* gen.: nutlet from sample Kłaj 55, × 25
9. *Sambucus* sp.: lower part of seed from sample Dąbrowica 76, × 30
10. cf. *Artemisia* sp.: achene from sample Kłaj 44, × 35
11. *Potamogeton* aff. *pygmaeus* Chandl.: fruit-stone from sample Pierzchów 27, × 30
12. *Potamogeton* cf. *heinkei* Mai: fruit-stone from sample Łapczyca 74, × 30
13. *Juncus* sp.: seed from Kłaj 53, × 50
14. cf. *Cyperus* sp.: fruit from sample Kłaj 39, × 20
15. *Cyperaceae:* fragment of root from sample Kłaj 46, × 50

Tablica VI

1. *Acer* sp. 1 (sect. *Palmata* Pax): owocek z próby Siedlec 58, × 12
2. *Acer* sp. 2 (sect. *Spicata* Pax): owocek z próby Pierzchów 30, × 12
3. *Aralia* aff. *hispida* Vent.: endokarp z próby Łapczyca 74, × 12
4. *Cornus* sp.: pestka z próby Suchoraba 24, × 10
5. cf. *Arctostaphylos* sp.: endokarp widziany z dwóch stron, próba Suchoraba 20, × 12
6. *Epacridicarpum* cf. *mudense* Chandl.: część owocu od strony wewnętrznej, próba Gdów 9, × ok. 15
7. *Scrophulariaceae* gen.: nasienie z próby Kłaj 44, × 50
8. *Labiatae* gen.: rozłupka z próby Kłaj 55, × 25
9. *Sambucus* sp.: dolna część nasienia z próby Dąbrowica 76, × 30
10. cf. *Artemisia* sp.: owocek z próby Kłaj 44, × 35
11. *Potamogeton* aff. *pygmaeus* Chandl.: pestka z próby Pierzchów 27, × 30
12. *Potamogeton* cf. *heinkei* Mai: pestka z próby Łapczyca 74, × 30
13. *Juncus* sp.: nasienie z próby Kłaj 53, × 50
14. cf. *Cyperus* sp.: orzeszek z próby Kłaj 39, × 20
15. *Cyperaceae:* fragment korzenia z próby Kłaj 46, × 50

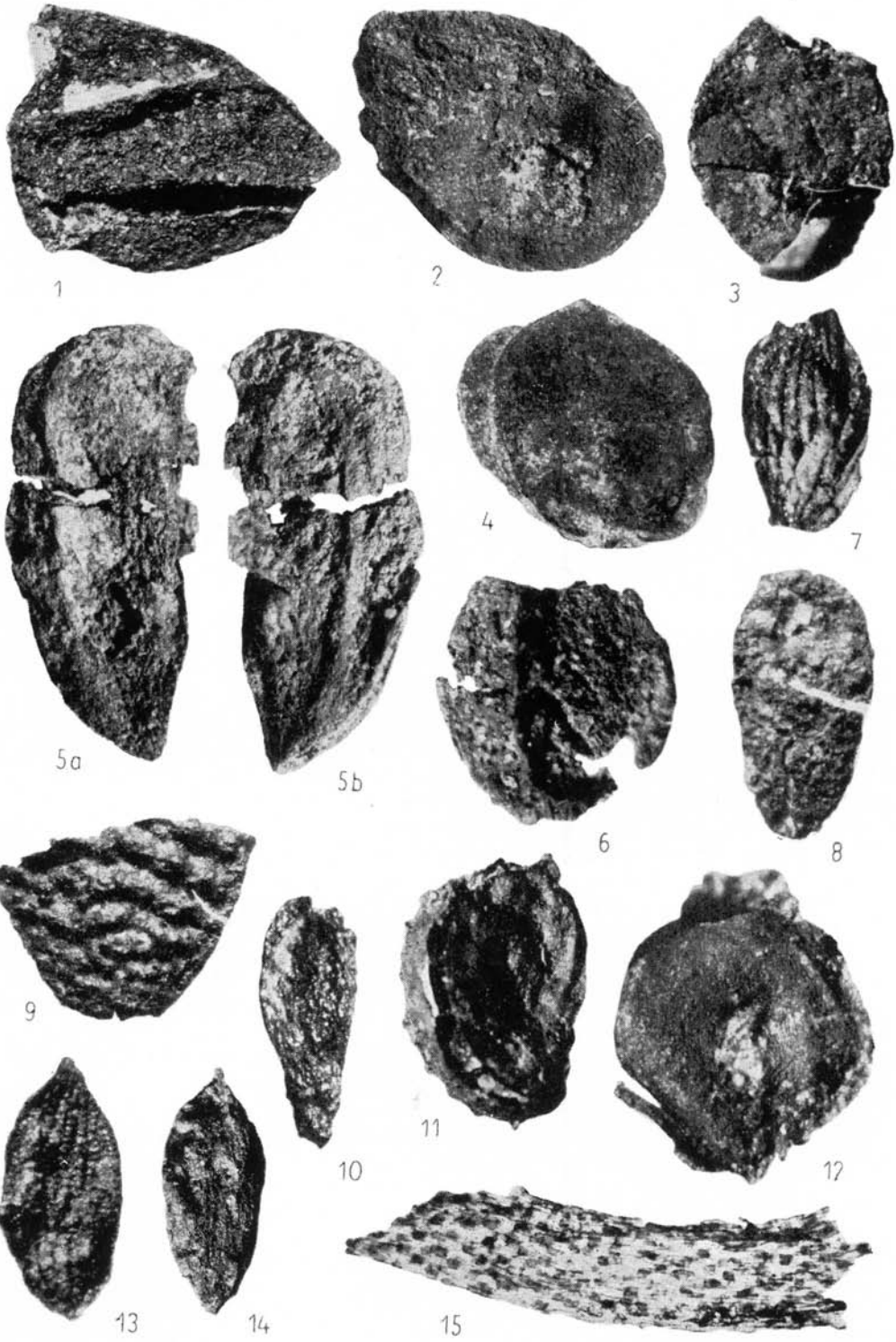
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Plate VII

1. *Scirpus* cf. *silvaticus* L.: fruit from sample Pierzchów 26, × 20
2. *Schoenoplectus* aff. *Tabernaemontani* (Gmel.) Palla: fruit from sample Suchoraba 22, × 17

3, 4. *Schoenoplectus* sp. 1: fruits from sample Siedlec 63, × 17

5, 6. *Schoenoplectus* sp. 2: fruits from sample Siedlec 63, × 17

7. *Carex* aff. *rostrata* Stokes: fruit from sample Suchoraba 22, × 20
8. *Carex* sp. 2: fruit from sample Łapczyca 74, × 20
9. *Heleocharis* sp.: fruit from sample Cichawa 25: *9 a, b* — part of fruit with cap on apex, × 22; *9 c* — sculpture of internal wall of fruit, × 40

10, 11. *Gramineae* gen. div.: fruits from samples Kłaj 55 and Kłaj 53, × 30

12. *Lemna* sp.: seed from sample Książnica 34, × 26
13. *Sparganium* cf. *camenzianum* Kirchh.: endocarp from sample Suchoraba 24, × 40

14—16. *Typha* cf. *elongata* Dorof.: seeds from samples Kłaj 46, 51, 40, × 35

17, 18. *Typha* aff. *maxima* Dorof.: seeds from samples Kłaj 46, 49, × 35

19. *Typha* aff. *pusilla* Dorof: seed from sample Siedlec 63, × 35

20—22. *Antherites* sp. div.: anthers from samples Pierzchów 29 and Kłaj 55, × 20

Tablica VII

1. *Scirpus* cf. *silvaticus* L.: owocek z próby Pierzchów 26, × 20
2. *Schoenoplectus* aff. *Tabernaemontani* (Gmel.) Palla: owocek z próby Suchoraba 22, × 17

3, 4. *Schoenoplectus* sp. 1: owocki z próby Siedlec 63, × 17

5, 6. *Schoenoplectus* sp. 2: owocki z próby Siedlec 63, × 17

7. *Carex* aff. *rostrata* Stokes: orzeszek z próby Suchoraba 22, × 20
8. *Carex* sp. 2: orzeszek z próby Łapczyca 74, × 20
9. *Heleocharis* sp.: owocek z próby Cichawa 25: *9 a, b* — część owocka z czapeczką na szczycie, *9 c* — skulptura wewnętrznej ściany owocka, × 40

10, 11. *Gramineae* gen. div.: ziarniaki z próby Kłaj 55 i Kłaj 53, × 30

12. *Lemna* sp.: nasienie z próby Książnice 34, × 26
13. *Sparganium* cf. *camenzianum* Kirchh.: endokarp z próby Suchoraba 24, × 40

14—16. *Typha* cf. *elongata* Dorof.: nasiona z próby Kłaj 46, 51, 40, × 35

17, 18. *Typha* aff. *maxima* Dorof.: nasiona z próby Kłaj 46, 49, × 35

19. *Typha* aff. *pusilla* Dorof.: nasienie z próby Siedlec 63, × 35

20—22. *Antherites* sp. div.: pylniki z próby Pierzchów 29 i Kłaj 55, × 20

M. Łańcucka-Środoniowa
Acta Palaeobotanica VII/1