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MAZOVIAN INTERGLACIAL AT KONIECZKI NEAR KŁOBUCK (SILESIAN-CRACOVIAN UPLAND)

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ABSTRACT. The aim of this work is to present an account of the development of the vegetation in the Woźniki-Wieluń Upland in the Mazovian Interglacial, and during the initial period of the subsequent glaciation, on the basis of the results of palaeobotanical studies (pollen and macrofossil analyses). Eleven local pollen assemblage zones (L PAZ), of which ten represent the Mazovian Interglacial, and six local macrofossil assemblage zones (L MAZ) have been distinguished. The flora list contains 251 taxa varying in rank, 106 of them identified to species level. A very high proportion of *Taxus* pollen, with a maximum exceeding 60%, is the characteristic feature of the pollen succession. Among the macrofossils, special attention should be given to *Aracites interglacialis*, an extinct species characteristic of the Mazovian floras, known from several sites in Poland. The succession from Konieczki is compared with those from three sites in the Woźniki-Wieluń Upland and with several other successions of the Mazovian Interglacial in Poland. The differences, caused mainly by the varying pollen proportions of *Taxus*, *Fraxinus* and *Pinus*, are connected with local conditions.

KEY WORDS: Mazovian Interglacial, pollen succession, pollen analysis, plant macrofossil analysis

INTRODUCTION

The paucity of well-documented sites of Pleistocene organogenic sediments in the Silesian-Cracovian Upland was the motivation for prospecting that region for appropriate deposits for palynological study. Serious difficulties in finding sufficiently thick layers of organogenic sediments in the southern part of the Upland led to consideration of its northern part, the Woźniki-Wieluń Upland. The idea of a palaeobotanical study of the sediments from the Konieczki site was suggested by Dr J. Lewandowski, who has been mapping in that region for some years.

Field investigation at Konieczki began in the autumn of 1992 and continued as a result of financial support from various sources. At first means were provided from the statutory research fund of the Department of Earth Sciences, Silesian University and later from the fund for the Department's own studies. A grant from the W. Szafer Foundation of Polish Botany in Kraków was also a substantial help. Geological studies and the final preparation of the results were supported by a grant-in-aid for Research Project KBN No 6 P04D 037 08.

Pollen diagrams for the Kuźnia Borecka, Gościęcin and Kuców sites were constructed on the basis of data from the Polish Palynological Database – Pleistocene at the W. Szafer Institute of Botany, PAScs, in Kraków.

GEOLOGICAL STRUCTURE, WITH SPECIAL ATTENTION TO QUATERNARY SEDIMENTS

The Konieczki site lies in the middle part of the Woźniki-Wieluń Upland, which forms the northern part of the Silesian-Cracovian Upland. The Woźniki-Wieluń Upland lies in the northern part of the Silesian-Cracovian monocline, also known as the Kraków-Wieluń monocline. It is composed of Mesozoic rocks, usually outcropping at the surface. The Wieluń graben is accepted as the north-western boundary of the monocline.

The greater part of the Woźniki-Wieluń Upland area is covered by Quaternary deposits, which form a layer varying in thickness. There is a general tendency for increased thickness towards the north, where the number of outcrops of the Jurassic substratum distinctly diminishes. The Quaternary deposits are thickest in the fossil river valleys, as exemplified by the Pankówka and Biała Oksza fossil valleys with deposits 75, and over 50 m thick, respectively (Bednarek et al. 1992, Haisig & Wilanowski 1988, 1990). Generally, however, the cover of the Pleistocene deposits ranges in depth from 10 to 20 m.

The deposits of the South Polish Glaciations do not outcrop at the surface, being known only from boreholes. They reach a substantial thickness only in fossil river valleys. In the southern and middle parts of the Upland the South Polish deposits are represented by one glacial zone (Haisig & Wilanowski 1983, Bednarek et al. 1992). In the northern part – north of Działoszyn – and also in the region of Brzeźnica Nowa, the glacial complex is distinctly bipartite; it is divided by a series of river sediments (Skompski 1971a, b). The boulder-clay does not form compact patches and is seldom more than a few metres thick; it often lies directly above the older substratum.

The Mazovian Interglacial is represented by river silts, sands and gravels and by organogenic deposits. Intensive river erosion created deep valleys, which were often cut down to the sub-Quaternary substratum.

Several sites of organogenic deposits referable to the Mazovian Interglacial occur in the Woźniki-Wieluń Upland and its close vicinity (Fig. 1). At Malice they are sandy gyttjas, about 1.4 m thick, covered by deposits of the Odra Glaciation. The determination of the age of the deposits was based on the results of pollen analysis (Haisig et al. 1983). Peat from the site at Herby, 1–2 m thick, is also referred to the Mazovian Interglacial (Haisig et al. 1983). The thickest profiles of organic formations occur at Radziechowice and Kolonia Dubidze. These are gyttjas, 5.4 and 3.2 m thick, respectively, covered only by silts and sands (Borówko-Dłużakowa 1980, 1981). At nearby Borki, peaty silts, 0.8 m in thickness, are covered by boulder-clay referred by Skompski to the Middle Polish Glaciation; the results of expert examination neither confirm nor disprove that the organic deposits are of Mazovian age (Borówko-Dłużakowa 1981). A palynological study of the deposits from Kuźnia Borecka carried out by Kuszell (1986, 1998) provided evidence for their assignment to the same interglacial.

The ice sheet of the Odra Glaciation covered the whole area of the Upland. The glacial deposits consist of sands, silts and glacilacustrine clays from both the ice sheet transgres-

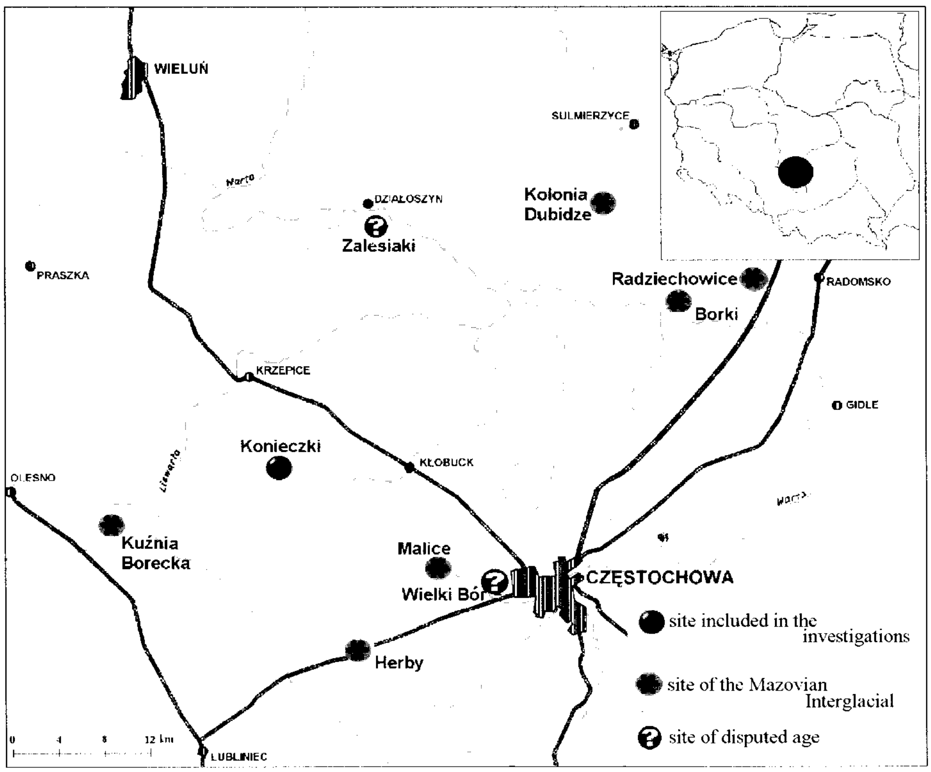

Fig. 1. Distribution of the Pleistocene sites of organogenic deposits in the Woźniki-Wieluń Upland and its immediate neighbourhood

sion and regression periods, glacifluvial sands and gravels, and boulder-clays.

The Pilica Interstadial (Interglacial?) caused erosion in river valleys. Evidence for this erosion is provided by the dissection of the boulder-clay in the larger river valleys. In the Upland area as a whole no deposits have been found which could unequivocally be assigned to the Pilica Interstadial (Interglacial?).

The Warta Glaciation embraced only the northern region of the Upland. The border of its maximum range extends along the line connecting Niwiska Górne, Wędrzynów, Trębaczew, Działoszyn, Węże, Giętkowizna, Parzymiechy, Jaworzno, Cieciułów, Sternalice and Kościeliska (Baraniecka & Sarnacka 1971, Haisig 1974).

The erosional processes taking place at the beginning of the Eemian Interglacial destroyed a considerable part of the deposits of the Middle Polish Glaciations. A new network of river valleys arose (Liswarta, Działoszyn gorge of the Warta) on the base of the marginal valleys from the Warta Glaciation period.

No organogenic deposits referable to the Eemian Interglacial on the basis of palynological studies have hitherto been found in the Woźniki-Wieluń Upland. The results of a pollen analysis of the peat from a site at Wielki Bór, carried out by Jastrzębska-Mamełka (Bardziński et al. 1986), showed a mixed pollen spectrum, suggesting a redeposition. Deposits from Wielki Bór have been referred both to the Mazovian Interglacial (Klimek 1966, Haisig & Wilanowski 1980) and to the Lublin Interglacial (Lewandowski 1988), as well as to the Eemian Interglacial (Bardziński et al. 1986).

The Vistula Glaciation was conspicuous mainly by an accumulation of sands and gravels in the river valleys, creating extensive terraces raised above the flood-plains (Bednarek et al. 1992).

In the Holocene the period of river erosion was followed by the accumulation of river sands, gravels and silts, which formed the contemporary flood-plain terraces. Peat sometimes occurs on the river terraces and in depressions without outflow, but its thickness does not usually exceed 2 m. One of the palaeobotanically documented Holocene sites is Wąsocz Górny (Orlicz 1967).

GEOLOGICAL SITUATION OF THE ORGANOGENIC SEDIMENTS

During exploratory boring for Bathonian ore-bearing clays carried out by the Institute of Geology in the 1950s, some organogenic deposits, 10 m in thickness, were drilled at Konieczki and described as peats. In 1992 another borehole was drilled about 300 m NE of the previous one, through financial support from the Silesian University.

At Konieczki the organogenic deposits lie very close to the surface and are covered only by sandy deposits (Tab. 1). The lack of a boulder-clay cover meant that their stratigraphic position was obscure. The fact that they were derived from the Mazovian Interglacial remained unknown until the results of the pollen analysis had been obtained; it was these which provided the basis for the present study.

The organogenic sediments overlie the formations of the South-Polish Glaciations (Fig. 2). They are mainly varigrained sands, probably of glacifluvial origin. In the western part, silts, exceeding 10 m in thickness, lie above the sands. Unfortunately, the brief description of the older drillings does not make a strict genetic interpretation possible, but it may be supposed that these silts also represent lacustrine sediments. Clay and underlying fine-grained sands fill up a deep fossil subglacial trough eroded in the Bathonian ore-bearing clays. As a result the maximum thickness of clay here exceeds 30 m. This clay probably represents the maximum stadial of the South-Polish Glaciation (Bednarek et al. 1992). Sands and gravels which occur round the fossil lake and partly cover the organic series represent glacifluvial sediments of the Odra Glaciation. Boulder-clay of that age in the lake zone was washed away and only small patches survived in the neighbourhood. The fossil lake series is covered also by sands and silts of fluvio-periglacial origin from the Vistula Glaciation and, locally, by sandy and peaty aggradations of Holocene age.

METHODS OF STUDY

This work is based on palaeobotanical studies conducted by the methods of pollen and plant macrofossil analysis, which were supplemented by geological studies.

Table 1. Lithological profile of deposits from the 1992 borehole

Depth [m]	Sediment description (symbols of Troels-Smith 1955)
0.0–0.35	Sandy soil
0.35–1.52	Fine and medium-grained sand, variously light yellow, light brown or orange-yellow
1.52–2.19	Sandy silt, grey, with occasional granitoid fragments and flints up to 3 cm in diameter nig. 2, sicc. 3, elas. 0, strf. 0, lim. sup. 0, Ag 2, Ga 2, Ld^3 +, Gs +, Gg (min+maj) +
2.19–6.12	Organic silt, dark grey, at the bottom dark brown nig. 3, sicc. 3, elas. 0, strf. 0, lim. sup. 2, Ag 2, Ga 1, Ld^3 1, As +; at the bottom Ld^3 2, Ag 1, Ga 1
6.12–6.73	Badly decayed peat, silty, black, brittle nig. 4, sicc. 3, elas. 1, strf. 0, lim. sup. 0, Th^3 3, Ag 1, Ga +
6.73–7.17	Sandy peat, dark brown with a large number of undecayed fragments of plants, brittle nig. 3+, sicc. 3, elas. 1, strf. 0, lim. sup. 1, Th^1 3, Ga 1, Ag +, Gs +, Tl +
7.17–7.46	Organic silt, peaty, dark brown nig. 3+, sicc. 3, elas. 0, strf. 0, lim. sup. 1, Ag 2, Th^2 2, Ga +
7.46–8.11	Badly decayed peat, dark brown, brittle nig. 3+, sicc. 3, elas. 1, strf. 0, lim.sup. 0, Th^3 3, Ag 1, Ga +, As +
8.11–9.82	Gyttja, dark brown nig.3+, sicc.3, elas.1, strf. 0, lim.sup.0, Ld^3 3, Ag 1, As +
9.82–10.07	Organic silt, dark brown nig. 3, sicc. 3, elas. 0, strf. 0, lim. sup. 1, Ag 3, Ld^3 1, As +, Ga +
10.07–10.87	Gyttja, dark brown nig. 3+, sicc. 3, elas. 1, strf. 0, lim. sup. 0, Ld^3 3, Ag 1, As +
10.87–12.19	Organic silt, dark brown nig. 3, sicc. 3, elas.0, strf. 0, lim. sup. 1, Ag 2, Ld^3 2, As +; at the bottom Ag 3, Ld^3 1, As +
12.19–12.59	Gyttja, dark brown, silty nig. 3+, sicc. 3, elas.1, strf. 0, lim. sup. 1, Ld^3 2, Ag 2, As +
12.59–13.52	Organic silt, dark brown nig. 3, sicc. 3, elas. 0, strf. 0, lim. sup. 0, Ag 3, Ld^3 1, As +
13.52–14.08	Gyttja, dark brown nig. 3, sicc.3, elas. 1, strf. 0, lim. sup. 2, Ld^3 3, Ag 1, As +
14.08–16.01	Organic silt, dark brown, in the lower part grey-brown with a hint of green and indistinct horizontal laminae, 1–2 mm thick nig. 3, sicc. 3, elas. 0, strf. 1, lim. sup. 4, Ag 3, Ld^3 1, As +
16.01–16.05	Varigrained sand, grey
16.05–17.50	Boulder-clay, dark grey with small limestone lumps, flints and granitoid fragments. The bottom part of the clay layer was not drilled through.

Samples for study were taken from the core, 0.11 m in diameter and 14.5 m in length, created by rotary flush drilling (URB 2.5).

The subject of sediment analysis were gyttjas, peats and organic silts. The study consisted of determining their grain size distribution (Myślińska 1992) and organic matter content (Oleksynowa et al. 1976). The results of both these analyses are presented in a pollen diagram (Fig. 3).

Samples designed for pollen analysis were macerated with 10% KOH, 10% HCl, 40% HF and subjected to Erdtman's acetolysis. Material thus prepared was mounted in glycerine.

The pollen spectrum of each sample was counted on at least two slides. Most of the pollen spectra were counted to include at least 1000 AP grains, except for 17 samples, in which, because of low frequencies, the AP total was smaller, but always above 500. The spores of Musci excl. *Sphagnum* were counted until the quantity of AP pollen reached 100 grains and then the number of spores was calculated in relation to the AP total.

Sediment samples for plant macrofossil analysis, 50 cm^3 in volume, were boiled with an addition of 10% KOH and next rinsed using sieves with 0.5 and 0.2 mm meshes.

The results obtained are presented in the form of a pollen diagram and a diagram of plant macrofossils. The POLPAL programme created by Dr Adam Walanus was used to prepare and draw both diagrams.

The pollen total of trees, shrubs and terrestrial herbaceous plants (ΣP) was applied as the basis for percentage calculations. The proportion of pollen of aquatic and reedswamp plants, spores of Pteridophyta and Bryophyta, and redeposited sporomorphs was computed in relation to the basic sum (ΣP) plus the contribution of the given taxon.

The taxa were divided into groups of trees and shrubs, herbs and dwarf-shrubs, Pteridophyta, Bryophyta, and aquatic and reedswamp plants. The herbaceous plants were additionally arranged in groups according to their soil moisture requirements (Zarzycki 1984). Within each group the taxa are arranged approximately in the order of their appearance.

The diagram of plant macrofossils is constructed in the form of a histogram showing the absolute numbers of specimens in a given sample. The identified taxa are grouped as follows: trees and shrubs, aquatic plants, reedswamp plants and those of wet habitats, and finally plants of moist/dry habitats. Within each group the taxa are arranged in stratigraphic order.

FLORA LIST

The flora list compiled on the basis of the results of pollen and plant macrofossil analyses contains 251 taxa of varied rank, of which 106 have been identified to species level.

The names of vascular plants in most cases have been taken from Mirek et al. (1995) and Ehrendorfer (1973). For extinct plants the names used are those given to the taxon by the author.

The flora list shows the occurrence or absence of a given taxon in each particular local pollen assemblage zone (Tab. 2).

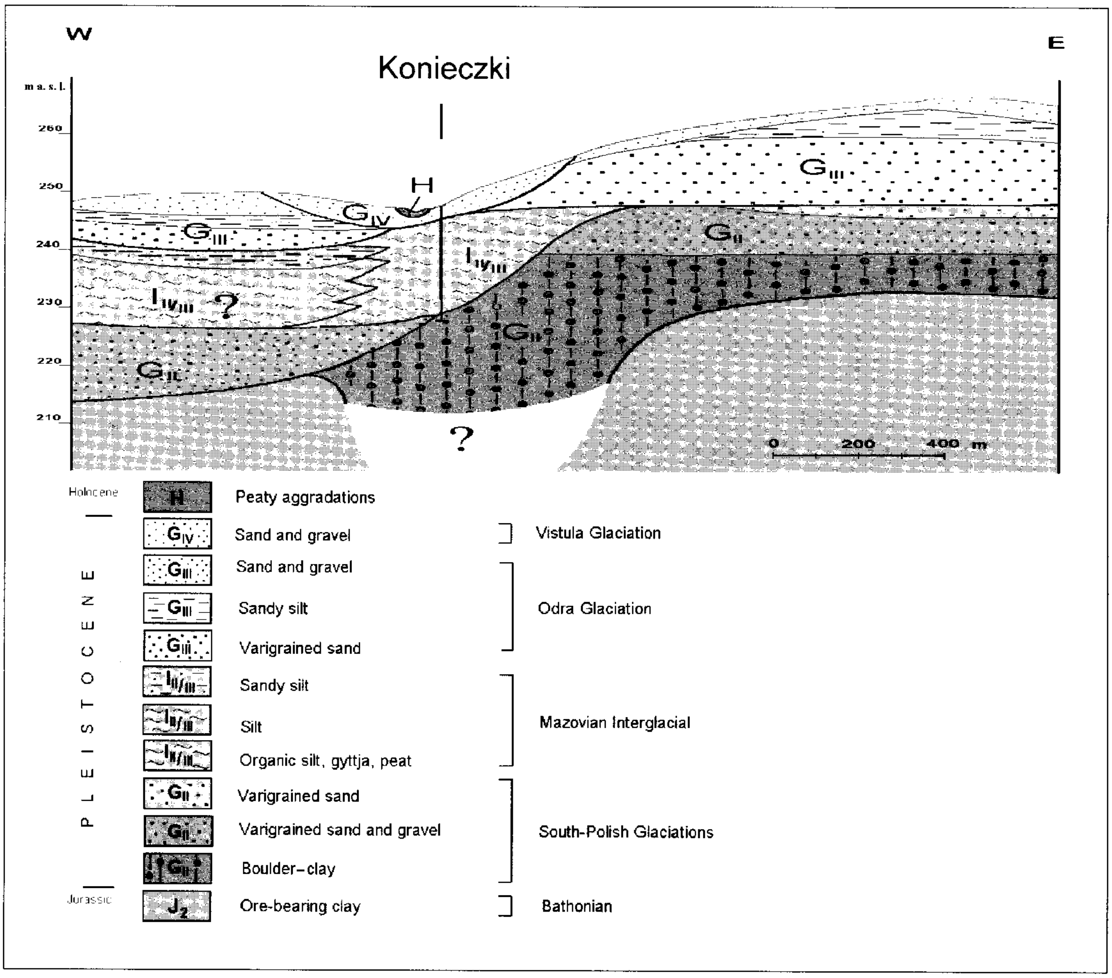

Fig. 2. Geological section through the Quaternary deposits of the Konieczki region

Table 2. Flora list

P – pollen
S – spores
M – macrospores, macrosporangia, microsporangia
O – oospores
+ – *Pediastrum*, Dinoflagellata occurrence
F – fruits, seeds, fruit scales etc.
N – hairs, needles, sclerotia etc.
W – wood
→ – spills over to a neighbouring zone
( ) – occurs exclusively in a disturbed layer of the given zone
♣ – maximum values or most frequent occurrence
• – occurs only in one sample within the given zone (1–3 specimens)
Taxa within the first disturbed layer, at a depth of 14.28–14.11 m, have been omitted from the list, because this layer occurs outside the stratigraphic division.

KONIECZKI	MAZOVIAN INTERGLACIAL										Early Glacial
	K-1 *Betula*	K-2 *Pinus-Betula*	K-3 *Betula-Alnus-Picea*	K-4 *Alnus-Picea-Fraxinus*	K-5 *Taxus-Alnus-Picea*	K-6 *Carpinus-Pinus-Betula*	K-7 *Carpinus-Abies-Alnus*	K-8 *Abies-Taxus-Corylus*	K-9 *Abies-Carpinus-Alnus*	K-10 *Pinus*	K-11 NAP-*Pinus-Betula*
	1	2	3	4	5	6	7	8	9	10	11
CHLOROPHYTA											
Hydrodictyaceae											
Pediastrum Meyen	+	+	+	+	+	+	+	+	+	+	+
CHAROPHYTA											
Characeae											
Chara fragilis Desvaux	–	–	–	–	–	–	–	–	–	O•	O♣
Nitellaceae											
Nitella opaca Ag.	–	–	–	–	–	–	–	–	O•	–	O♣
MYCOTA											
Hyphomycetes											
Cenococcum graniformae (Sow.) Ferd. & Winge	–	–	–	–	–	–	–	–	N	N•	N
BRYOPHYTA											
Musci (excl. *Sphagnum* Ehrh.)	S	S	S	S	S	S	S	S	S	S	S♣
Sphagnaceae											
Sphagnum Ehrh.	S	S	S	S	S	S	S	S	S	S	S♣
PTERIDOPHYTA											
Filicales monolete	S	S	S	S	S	S	S	S	S	S	S
Aspidiaceae											
cf. *Polystichum* Roth	–	–	–	–	–	–	–	–	–	S	–
Equisetaceae											
Equisetum L.	–	S	S•	S	S	–	–	–	S	–	S
Huperziaceae											
Huperzia selago (L.) Bernh. ex Schrank & Mart.	–	–	S•	S	S	S•	–	–	S•	–	S
Hypolepidaceae											
Pteridium aquilinum (L.) Kuhn	–	–	S•	S	S	S	S	S	S	S	S

Table 2. Continued

	1	2	3	4	5	6	7	8	9	10	11
Isoëtaceae											
Isoëtes cf. *lacustris* L.	–	–	–	S	S	–	–	–	–	–	–
Lycopodiaceae											
Diphasiastrum complanatum (L.) Holub type	–	S•	–	–	S•	–	S•	–	–	–	–
Lycopodium annotinum L.	S	S	S•	S	S	S•	S•	–	S	S•	S
Lycopodium clavatum L.	–	–	–	–	S•	S	–	–	S	S•	S
Ophioglossaceae											
Botrychium Sw.	–	S	–	–	S•	–	S	–	S	–	S
Osmundaceae											
Osmunda cinnamomea L.	–	–	–	–	S♣	S	S	S	S	S	S
Osmunda regalis L. /*O. claytoniana* L.	–	–	–	S	S	S	S•	–	S	S•	S
Polypodiaceae s. str.											
Polypodium vulgare L.	–	–	–	S•	S•	–	S	S•	S	–	S
Thelypteridaceae											
Thelypteris palustris Schott	S	S	S•	S	S	S	S	S	S	S	S
Salviniaceae											
Salvinia natans (L.) All.	–	–	–	–	M	M	M	M	M♣	M	M
Selaginellaceae											
Selaginella helvetica (L.) Spring	–	–	–	–	–	–	–	–	–	–	M
Selaginella selaginoides (L.) P. Beauv. ex Schrank & Mart.	–	–	–	–	–	–	–	–	–	M•	SM
GYMNOSPERMAE											
Cupressaceae											
Juniperus L.	P	P	P	P	P	P	P•	P•	P	P	P♣
Ephedraceae											
Ephedra distachya L. type	–	–	–	–	–	–	–	–	–	–	P
Ephedra fragilis Desf. type	–	P•	–	–	–	–	–	–	–	–	P
Ephedra cf. *strobilacea* Bunge	–	–	–	–	–	–	–	–	–	–	P•
Pinaceae											
Abies Mill.	–	–	–	P	P	P	P	P	P♣	P	P
Abies alba Mill.	–	–	–	–	–	–	–	N	–	–	–
Larix Mill.	–	P	P	P	PN•	PN•	–	–	P	P	P♣
Picea abies (L.) H. Karst.	P•	P	P	PN•	P♣	P	P	P	P	P	P
Picea Dietr.	–	–	–	–	–	–	–	–	W•	–	–
Picea Dietr. vel *Larix* Mill.	–	W•	–	–	–	–	–	–	–	–	–
Pinus cf. *cembra* L.	–	–	P	P•	–	–	–	–	–		–
Pinus cembra L.	–	–	–	–	–	–	–	–	–	–	N•
Pinus sylvestris L.	–	–	–	–	–	–	–	–	N→	W•	NF•
Pinus cf. *sylvestris* L.	–	–	–	–	–	–	–	–	N→	–	N•
Pinus sylvestris L. type	P	P	P	P	P	P	P	P	P	P♣	P♣
Pinus L.	–	–	–	–	–	–	–	–	–	–	W
cf. *Pinus* L.	–	–	–	–	–	–	–	F•	–	–	–
Taxaceae											
Taxus L.	–	–	–	P	P♣	P	P	P	P	P	P
ANGIOSPERMAE											
Aceraceae											
Acer L.	–	P	P•	P	P	P	P	P	P	–	P•

Table 2. Continued

	1	2	3	4	5	6	7	8	9	10	11
Alismataceae											
Alisma plantago-aquatica L.	–	–	–	–	–	–	–	–	–	–	F•
Sagittaria L.	–	–	–	–	–	–	–	–	–	–	P
Sagittaria sagittifolia L.	–	–	–	–	–	–	–	–	–	F•	F
Apiaceae (Umbelliferae)											
Bupleurum L.	–	–	–	–	–	–	–	P•	P•	–	P
Cicuta virosa L.	–	–	–	–	–	–	–	–	–	–	F•
Pimpinella L.	–	–	–	–	–	–	–	–	–	–	P
Apiaceae undiff.	P	P	P	P	P	P	P	P	P	P	P♣
Aquifoliaceae											
Ilex aquifolium L. type	–	–	–	P•	P•	P•	–	P•	P•	–	–
Araliaceae											
Hedera helix L.	–	–	P•	P	P	P•	P	P	P	–	–
? Araceae											
Aracites interglacialis Wieliczk.	–	–	–	–	–	–	–	–	F	F•	F
Asteraceae											
Anthemis L. type	–	P•	–	P	P	P•	P•	–	P	P	P♣
Artemisia L.	P	P	P	P	P	P	P	P	P	P	P♣
Aster L. type	–	–	–	P	–	–	–	–	P	–	P♣
Carduus L.	–	–	–	–	–	–	–	–	–	–	P
Cirsium Mill.	P•	–	P•	–	–	–	–	–	–	–	P
Senecio L. type	–	–	–	–	–	–	–	–	–	–	P•
Solidago L. type	–	–	P	P	P	P	P	–	P•	P•	P♣
Asteraceae undiff.	–	–	–	–	P•	–	–	–	–	–	P
Balsaminaceae											
Impatiens L.	–	–	–	–	P•	–	–	–	–	–	–
Betulaceae											
Alnus Mill.	–	–	–	–	W•	–	–	–	W	–	W
Alnus glutinosa (L.) Gaertn. type	P	P	P	P♣	P	P	P	P	P	P	P
Alnus Mill./*Betula* L.	–	–	–	–	–	–	–	–	W•	–	W•
Betula sect. Albae	F•	–	F•	–	F	F	F•	–	F	F•	F
Betula cf. *humilis* Schrank	–	–	–	–	–	–	–	–	–	F•	F
Betula nana L.	–	–	–	–	F•	–	–	–	F	–	PF♣
Betula cf. *nana* L.	–	–	–	–	–	–	–	–	–	F	F
Betula cf. *pendula* Roth	F	F	F•	F	F•	F	F	–	F	–	F
Betula pubescens Ehrh.	F•	F•	–	F•	–	F•	–	–	F	–	F•
Betula cf. *pubescens* Ehrh.	F	F•	F•	F•	–	–	–	–	F	F•	F
Betula L.	–	–	–	–	–	–	–	–	–	–	W
Betula L. undiff.	P♣	P	P	P	P	P	P	P	PF•	P	PF
Boraginaceae											
Symphytum L.	–	–	–	–	–	P•	P•	–	–	–	–
Brassicaceae (Cruciferae)	–	–	–	–	P	–	P•	–	P	P	P♣
Rorippa palustris (L.) Besser	–	–	–	–	–	–	–	–	–	F•	F
Butomaceae											
Butomus umbellatus L.	–	–	–	–	–	–	P	P•	P	–	(P•)
Buxaceae											
Buxus L.	–	–	–	–	P	P	P	P	P♣	P	P

Table 2. Continued

	1	2	3	4	5	6	7	8	9	10	11
Callitrichaceae											
Callitriche autumnalis L. em. Wahlenb.	–	–	–	–	–	–	–	–	F•	F	F♣
Campanulaceae											
Campanula L.	–	–	–	P•	–	–	–	–	–	P•	P
Cannabaceae											
Humulus lupulus L.	P	P	P	P♣	P	P	P	P	P	P•	P
Caprifoliaceae											
Sambucus nigra L.	–	–	–	–	P	–	–	–	–	–	P
Sambucus racemosa L.	–	–	P•	P•	P•	–	P•	P•	–	–	P
Viburnum L.	–	–	P•	P	P	P	P	P	P	–	P
Caryophyllaceae											
Cerastium L.	–	–	–	–	–	–	–	–	–	–	F
Cerastium L. type	P•	P•	–	–	–	P•	–	P•	P	P•	P♣
Dianthus L. type	–	–	–	–	–	–	–	–	–	–	P
Gypsophila fastigiata L. type	–	–	–	–	–	–	–	–	–	–	P•
Melandrium Röhl. type	–	–	–	–	–	–	–	–	–	–	P•
Scleranthus annuus L.	–	–	–	–	–	–	–	–	–	–	P•
Scleranthus perennis L.	–	–	–	–	–	–	–	–	–	–	P•
Silene L. type	–	–	–	–	–	–	–	–	–	–	P
Spergula arvensis L. type	–	–	–	–	–	–	–	P•	P•	–	–
Stellaria holostea L.	–	–	–	–	P•	–	–	–	–	–	–
Stellaria nemorum L.	–	–	–	–	–	–	–	–	–	–	F
Stellaria palustris Retz.	–	–	–	–	–	–	–	–	–	–	F
Caryophyllaceae undiff.	–	–	–	–	P•	–	–	–	P	–	P♣
Celastraceae											
Euonymus L.	–	–	–	–	–	–	–	–	P	–	–
Ceratophyllaceae											
Ceratophyllum L.	–	–	–	–	N	N•	N	N	N	N	N
Ceratophyllum demersum L.	–	–	–	–	–	–	–	–	F•	–	F•
Chenopodiaceae	P	P•	–	P	P	P	P	–	P	P	P♣
Cistaceae											
Helianthemum canum (L.) Baumg. / *H. alpestre* (Jacq.) Dunal	–	–	–	–	–	–	–	–	–	–	P
Helianthemum nummularium (L.) Mill. type	–	–	–	–	–	–	–	–	–	–	P
Cichoriaceae	–	P•	–	–	–	–	–	P•	P•	P•	P♣
Cornaceae											
Cornus sanguinea L.	–	–	P•	P•	P•	–	P•	–	–	–	–
Corylaceae											
Carpinus L.	P	P•	P•	P	P	P	P♣	P	P	P	P
Corylus L.	–	P	P	P	P	P	P	P♣	P	P	P
Cyperaceae											
Carex canescens L.	–	–	–	–	–	–	–	–	–	–	F•
Carex cf. *cespitosa* L.	–	–	–	–	–	–	–	–	F•	–	F
Carex elata All.	–	–	–	–	–	–	–	–	F	–	F
Carex cf. *elata* All.	–	–	–	–	–	–	–	–	–	F	F
Carex gracilis Curtis	–	–	–	–	–	–	–	–	F	F	F
Carex cf. *gracilis* Curtis	–	–	–	–	–	–	–	–	–	–	F

Table 2. Continued

	1	2	3	4	5	6	7	8	9	10	11
Carex cf. *panicea* L.	–	–	–	–	–	–	–	–	–	–	F
Carex pseudocyperus L.	–	–	–	–	–	–	–	–	F•	F	F
Carex rostrata Stokes	F•	–	–	–	–	–	–	–	F	F	F♣
Carex cf. *rostrata* Stokes	–	–	–	–	–	–	–	–	–	–	F
Carex cf. *vesicaria* L.	–	–	–	–	–	–	–	–	–	–	F•
Carex sect. Acutae	–	–	–	–	–	–	–	–	–	F•	F♣
Carex L. undiff.	–	–	–	–	–	–	–	–	F•	F•	F♣
Dulichium spathaceum Pers.	–	–	–	–	–	–	–	–	–	–	F
Eleocharis palustris (L.) Roem. & Schult.	–	–	–	–	–	–	–	–	–	–	F
Eleocharis cf. *palustris* (L.) Roem. & Schult.	–	–	–	–	–	–	–	–	–	–	F•
Eleocharis palustris (L.) Roem. & Schult./ *E. mamillata* (H. Lindb.) H. Lindb. ex Dörfl.	–	–	–	–	–	–	–	–	F•	F•	F♣
Eleocharis praemaximoviczii Dorof.	–	–	–	–	–	–	–	–	F	F	F♣
Schoenoplectus lacustris (L.) Palla	–	–	–	–	–	–	–	–	–	–	F
Scirpus atroviroides Dorof.	–	F•	–	–	F•	–	–	–	F	F	F♣
Cyperaceae	P	P	P	P	P	P	P	P	P	P	P♣
Dipsacaceae											
Knautia L.	–	–	–	–	–	–	–	–	–	–	P
Elaeagnaceae											
Hippophaë rhamnoides L.	P•	–	–	–	–	–	–	–	–	–	P
Ericaceae											
Andromeda polifolia L.	–	–	–	–	–	–	–	–	F•	–	–
Arctostaphylos L.	–	–	–	–	–	–	–	–	–	–	P•
Calluna vulgaris (L.) Hull	–	P	P•	P	P	P	P	P	P	P	P♣
Chamaedaphne calyculata (L.) Moench.	–	–	–	–	–	–	–	–	F•	–	–
Vaccinium L. type	–	P	P•	P	P	–	–	–	–	–	–
Ericaceae undiff.	–	–	P•	P•	P	–	P	P•	P	P•	P♣ F•
Euphorbiaceae											
cf. *Euphorbia*	–	–	–	–	P•	–	–	–	–	–	–
Mercurialis cf. *perennis* L.	–	–	–	–	–	–	–	–	P•	–	–
Fabaceae	–	–	–	–	–	P	–	–	(P•)	–	P
Fagaceae											
Fagus L.	–	–	–	–	–	–	P•	–	P♣	P	P
Quercus L.	P	P	P	P	P	P	P	P♣	P	P	PW•
Gentianaceae											
Gentiana cf. *nivalis* L.	–	–	–	–	–	–	–	–	–	–	P
Haloragaceae											
Myriophyllum spicatum L.	–	P	P	P	P	–	–	P•	P	PF•	P♣ F•
Myriophyllum verticillatum L.	–	–	–	–	P•	–	–	–	(P•)	P•	P
Myriophyllum cf. *verticillatum* L	–	–	–	–	–	–	–	–	–	–	F•
Hippuridaceae											
Hippuris vulgaris L.	–	–	–	–	–	–	–	–	–	–	F•
Hydrocharitaceae											
Stratiotes aloides L.	–	–	–	–	–	–	–	–	P•	–	P•
Juglandaceae											
Pterocarya Kunth.	–	–	–	–	–	–	–	–	P♣	P	P

Table 2. Continued

	1	2	3	4	5	6	7	8	9	10	11
Lamiaceae (Labiatae)											
Lycopus L.	–	–	–	–	–	–	P•	–	–	–	P•
Lycopus europaeus L.	–	–	–	–	–	–	–	–	–	–	F•
Mentha L.	–	–	–	–	–	–	–	–	–	–	F•
Mentha L. type	–	–	–	–	–	–	–	–	(P)	–	P
Stachys sylvatica L. type	–	–	–	–	P•	–	P	P•	P	–	P•
Lentibulariaceae											
Utricularia L.	–	–	–	–	–	–	–	–	–	–	P
Loranthaceae											
Viscum L.	–	–	–	–	P•	–	P	P	P	–	(P•)
Lythraceae											
Lythrum L.	–	–	–	–	P•	P	–	–	P	–	P
Menyanthaceae											
Menyanthes trifoliata L.	–	–	–	–	P•	–	–	–	PF•	PF•	P♣F
Najadaceae											
Najas flexilis (Willd.) Rostk. & W.L.E.Schmidt	–	–	–	–	F•	–	–	–	F	F	F♣
Najas minor All.	–	–	–	–	–	–	–	–	F•	–	–
Nymphaeaceae											
Nuphar Sm.	–	–	–	–	–	–	F•→	–		–	–
Nuphar lutea (L.) Sibth. & Sm.	–	–	–	P•	P	–	P	P	P	–	P
Nymphaea L.	–	–	–	–	–	–	F•→	–	–	–	–
Nymphaea alba L.	–	–	–	–	P•	–	–	–	P	–	P
Nymphaea candida C. Presl	–	–	–	–	P	–	P	–	P	–	P
Onagraceae											
cf. *Chamaenerion* Scop.	–	–	–	–	–	–	–	–	(P•)	–	P
cf. *Epilobium* L.	–	–	–	–	–	–	–	P•	–	–	P•
Oleaceae											
Fraxinus L.	P	P	P	P♣	P	P	P	P	P	P	P
Ligustrum L.	–	–	–	–	P	P	P•	P	P	–	–
Plantaginaceae											
Plantago major L.	–	–	P•	P•	–	–	P•	–	P	–	P♣
Plantago maritima L. s.l.	–	P•	–	P	P•	–	–	–	P	P•	P
Plantago maritima L. s.str.	–	–	–	–	P•	–	–	P•	–	–	P•
Plantago media L.	–	–	–	–	–	–	–	–	–	–	P
Plumbaginaceae											
Armeria maritima (Mill.) Willd. A-type	–	–	–	–	P	–	–	–	–	–	P
Armeria maritima (Mill.) Willd. B-type	–	–	–	–	–	–	–	–	–	–	P
Poaceae (Gramineae)											
Phragmites Adans.	–	P	P•	P	P	P	P•	P	P	P	P♣
Poaceae	–	–	–	–	–	–	–	–	–	–	F
Poaceae undiff.	P	P	P	P	P	P	P	P	P	P	P♣
Polemoniaceae											
Polemonium L.	–	–	–	–	–	–	–	–	–	–	P
Polygonaceae											
Polygonum amphibium L.	–	–	–	–	P•	P	–	–	–	–	–
Polygonum aviculare L. type	–	–	–	P	P•	–	–	–	–	–	P
Polygonum bistorta L./*P. viviparum* L.	–	–	–	–	–	–	–	–	(P•)	P•	P

Table 2. Continued

	1	2	3	4	5	6	7	8	9	10	11
Polygonum persicaria L. type	–	–	–	–	–	–	–	–	(P•)	–	P
Rumex acetosa L. type	–	P	P•	–	P•	–	–	–	P	P•	P♣
Rumex acetosella L.	–	–	–	–	–	–	–	–	–	–	F
Rumex acetosella L. type	P•	P•	–	P	P	P	–	P	P	–	P♣
Rumex crispus L. type	–	–	–	–	–	–	–	–	–	–	P•
Rumex maritimus L.	–	–	–	–	–	–	–	–	–	–	F
Rumex sect. Acetosae	P•	P•	–	–	–	–	P•	P	P	P•	P♣
Potamogetonaceae											
Potamogeton compressus L.	–	–	–	–	–	–	–	–	–	–	F
Potamogeton dorofeevii Wieliczk.	–	–	–	–	–	–	–	–	–	–	F•
Potamogeton friesii Rupr.	–	–	–	–	–	–	–	–	–	F•	-
Potamogeton cf. *gramineus* L.	–	–	–	F•	–	–	–	–	–	–	F
Potamogeton cf. *goretskyi* Dorof.	–	–	–	–	–	–	–	–	–	–	F•
Potamogeton natans L.	–	–	–	–	–	F•	–	–	F♣	–	–
Potamogeton cf. *natans* L.	–	–	–	–	–	–	–	–	–	–	F•
Potamogeton obtusifolius Mert. & W.D.J.Koch	–	–	–	–	–	–	–	–	F•	–	F
Potamogeton cf. *obtusifolius* Mert. & W.D.J. Koch	–	–	–	–	–	–	–	–	–	–	F•
Potamogeton panormitanus Biv.	–	–	–	–	–	–	–	–	–	F•	F
Potamogeton panormitanoides Dorof.	–	–	–	–	–	–	F•	–	–	–	F
Potamogeton cf. *panormitanoides* Dorof.	–	–	–	–	–	–	–	–	–	–	F
Potamogeton perfoliatus L.	–	–	F•	–	–	–	–	–	–	–	F
Potamogeton cf. *perfoliatus* L.	–	–	–	–	–	–	F•	–	–	–	–
Potamogeton praelongus Wulfen	–	–	–	–	–	–	–	–	–	–	F
Potamogeton cf. *praelongus* Wulfen	–	–	–	–	–	–	F•	–	–	–	–
Potamogeton pusillus L.	–	–	–	–	–	–	–	–	–	–	F
Potamogeton cf. *pusillus* L.	–	–	–	–	–	–	–	–	–	–	F
Potamogeton cf. *sarjanensis* Wieliczk.	–	–	–	–	–	–	–	–	–	–	F•
Potamogeton sect. Coleogeton	–	–	–	–	–	–	–	–	P	–	-
Potamogeton sect. Eupotamogeton	–	–	P	P•	–	P•	P•	P•	P♣	P	P
Potamogeton L. undiff.	–	–	–	–	–	F•	F•	–	–	–	F
Primulaceae											
Hottonia palustris L.	–	–	–	P•	–	–	–	–	–	–	–
Lysimachia nemorum L.	–	–	–	–	–	–	–	–	P	–	P
Lysimachia nummularia L.	–	–	–	–	–	–	–	–	P•	–	–
Lysimachia thyrsiflora L.	–	–	–	–	–	–	–	P•	P	–	P
Lysimachia vulgaris L. type	–	–	–	–	–	–	P•	–	P•	–	P•
Ranunculaceae											
Aconitum L.	–	–	–	–	–	–	–	–	–	–	P•
Anemone L. type	–	–	–	–	–	–	–	–	P	–	P
Batrachium S.F. Gray	–	–	–	–	–	–	–	–	–	F	F♣
Caltha L. type	–	P•	–	–	P	–	–	–	P	P•	P♣
Ranunculus acris L. type	–	P	–	P	P	P•	–	–	P	P•	P♣
Ranunculus flammula L. type	P•	P	P	P	–	–	–	P	P	P	P♣
Ranunculus sceleratus L.	–	–	–	–	–	–	–	–	F	F	F♣
Ranunculus L. undiff.	–	–	–	F•	–	–	–	–	–	–	–

Table 2. Continued

	1	2	3	4	5	6	7	8	9	10	11
Thalictrum L.	P•	P	P	P•	P	P•	–	–	P	P	P♣
Trollius L.	–	–	–	–	–	–	–	–	–	–	P•
Rhamnaceae											
Frangula alnus Mill.	–	P	P	P	P	P	P	P	P	P	P•
Rosaceae											
Comarum palustre L.	–	–	–	–	–	–	–	–	PF•	F•	PF
Filipendula Mill.	–	P	P•	P	–	P•	P	P	P	P•	P♣
Geum L.	–	–	–	–	–	–	–	–	–	–	P
Potentilla L.	–	–	–	–	P•	–	–	–	P	P•	P
Potentilla cf. *supina* L.	–	–	–	–	–	–	–	–	–	–	F
Potentilla L. type	–	–	–	–	–	–	–	–	(P•)	P	P
Potentilla L. undiff.	–	–	–	–	–	–	–	–	–	F	–
Rosa L.	–	–	–	–	P	–	–	–	–	–	P
Rubus L.	–	–	–	–	–	–	–	–	PF	–	F•
Sanguisorba officinalis L. (2n=28)	–	–	–	–	–	–	–	–	–	P•	P
Sanguisorba officinalis L. (2n=56)	–	–	–	–	–	–	–	–	–	–	P
Sorbus L.	–	–	–	–	P	P	–	–	P•	–	P•
Rosaceae undiff.	P•	P•	–	P	P	P•	P•	P	P	P	P♣
Rubiaceae	P•	P	P•	P•	P	P	P•	P•	P	P	P♣
Salicaceae											
Populus tremula L. type	–	P	P•	P	P	P	P	–	P	P•	P♣
Salix L.	–	–	–	–	–	–	–	–	–	–	W
Salix glauca (auct.) type	P	P	P	P	P	P	P	P	P	P	P♣
Salix pentandra L. type	P•	–	P	P•	P	P	P	P	P	P	P♣
Saxifragaceae											
Saxifraga cernua L. type	–	–	–	–	–	–	–	–	–	–	P
Saxifraga hirculus L. type	–	–	–	–	–	–	–	–	P•	–	P•
Scrophulariaceae											
Rhinanthus L. type	–	–	–	–	P	–	–	–	–	–	P
Scrophularia L. type	–	–	–	–	–	–	–	–	P•	–	P•
Veronica L.	–	–	–	–	–	–	–	–	(P•)	–	P
Sparganiaceae											
Sparganium L. type	P	P•	P	P	P	P	P	P	P	P	P♣
Tiliaceae											
Tilia cordata Mill. type	–	P	P	P♣	P	P	P	P	P	P•	P
Tilia platyphyllos Scop. type	–	–	–	P	–	–	–	–	–	–	–
Trapaceae											
Trapa L.	–	–	–	–	P•	–	P•	P•	PN F•	–	–
Typhaceae											
Typha latifolia L.	–	P	–	P	P	P•	P•	P	P	P	P♣
Typha L.	–	F	–	–	F•	–	–	–	F	F	F
Ulmaceae											
Celtis L.	–	–	–	–	–	–	–	–	P	–	–
Ulmus L.	–	P	P	P♣	P	P	P	P	P	P	P
Urticaceae											
Urtica dioica L.	–	P•	F•	–	–	–	P•	P	–	–	FP

Table 2. Continued

	1	2	3	4	5	6	7	8	9	10	11
Valerianaceae											
Valeriana L.	–	–	–	–	–	–	–	–	–	P•	P
Violaceae											
Viola arvensis Murray type	–	–	–	–	–	–	–	–	P•	–	–
Viola palustris L. type	–	–	–	–	–	–	–	–	–	–	P
Vitaceae											
Vitis L.	–	–	–	–	P	–	P	P♣	P	–	–
Zannichelliaceae											
Zannichellia palustris L.	–	–	–	–	–	–	–	–	–	–	F
Rebedded	–	–	–	–	–	–	–	–	–	–	P
Carya Nutt.	–	–	–	–	–	–	–	–	–	–	P
Liquidambar L.	–	–	–	–	–	–	–	–	–	–	P•
Nyssa L.	–	–	–	–	–	–	–	–	–	–	P
Sciadopitys S. et Z.	–	–	–	–	–	–	–	–	–	–	P
Taxodiaceae/Cupressaceae	–	–	–	–	–	–	–	–	–	–	P
Dinoflagellata	–	–	–	–	–	–	–	–	–	–	+

REMARKS ON SOME DETERMINATIONS

The flora of Konieczki comprises taxa determined on the basis of identifications of pollen grains, spores, seeds, fruits and the vegetative parts of plants.

The determinations of pollen grains were based on numerous publications, containing detailed descriptions and keys. However, in many cases, notably those of the more difficult and rare taxa, the comparative slide collection of the W. Szafer Institute of Botany, PAScs, in Kraków was the basis of determinations. The determinations of plant macrofossils were, on the whole, performed in the above-mentioned Institute of Botany. In this case the comparative collection of fruits and seeds of the Institute was used to a still greater extent. The full documentation of the results of the pollen analysis is stored in the Department of Earth Sciences, Silesian University, at Sosnowiec. The determined plant macrofossils will be transferred to the Palaeobotanical Museum of the W. Szafer Institute of Botany, PAScs, in Kraków.

POLLEN ANALYSIS

The terminology used in the descriptions of sporomorphs is that adopted by Punt et al. (1994).

Pteridophyta

Isoëtes cf. *lacustris* L. (Pl. 1 fig. 21) – 141 microspores, monolete, most frequently 40×25 µm in size; laesura long, about 35 µm (Erdtman et al. 1961).

Osmunda cinnamomea L. (Pl. 1 fig. 23) – 117 spores, trilete, large, almost circular in equatorial outline. Baculate elements separated (Andersen 1961).

Osmunda regalis L./*O. claytoniana* L. (Pl. 1 fig. 22) – 34 spores, trilete, large, preserved in fragments. Sculpture elements on surface fused together into a reticulate pattern (Andersen 1961).

Salvinia natans (L.) All. – numerous fragments of microsporangia. Whole microsporangia only sporadically present. Spumous structure of microsporangia and microspores preserved in it clearly visible. The microsporangia were identified as those of *Salvinia natans* on the basis of the presence of macrosporangia and macrospores of this species.

Gymnospermae

Ephedra cf. *strobilacea* Bunge (Pl. 1 fig. 8) – one very long and narrow grain, polyplicate, with 11 straight unbranched meridional grooves (Welten 1957).

Taxus L. (Pl. 1 figs 1–4) – very many pollen grains, all well preserved, with typical splits and a system of exine folds (Beug 1961); gemmae varying in size, densely arranged.

Angiospermae

Betula nana L. (Pl. 1 fig. 9) – numerous pollen grains, up to 21µm in diameter, more or less circular in outline, with very flat vestibulum (Erdtman et al. 1961, Praglowski 1962).

Buxus L. – 465 pollen grains, periporate, with very fine reticulate pattern.

Celtis L. (Pl. 1 figs 5–6) – four pollen grains with three pores surrounded by fairly narrow annulus. Pores somewhat sunken. Grains of more or less circular equatorial outline, 30–33 µm in diameter. Columellae on surface distinct, irregularly scattered (Faegri et al. 1989).

Pterocarya Kunth. (Pl. 1 fig. 7) – stephanoporate pollen grains, 201 in number, with 5–7 pores; microsculpture characteristically regularly dotted (Faegri & Iversen 1978).

Vitis L. – 64 pollen grains, mostly 20–23×16–19 µm in size, tricolporate, irregularly per-reticulate. Furrows narrow, pores characteristic, small and covered (Faegri et al. 1989).

Aconitum L. (Pl. 1 fig. 16) – one pollen grain, 37×24 µm in size. Granules much more clearly visible in the furrows than are the columellae on the grain surface (Faegri et al. 1989).

Gentiana cf. *nivalis* L. – two tricolporate pollen grains; columellae distinct, reticulum or striae visible according to focusing (Faegri et al. 1989).

Hottonia palustris L. (Pl. 1 fig. 15) – one tricolporate pollen grain (18×15 µm), distinctly per-reticulate. Lumina subequal, not decreasing towards the furrows (Moore et al. 1991).

Impatiens L. – a pollen grain with four straight furrows, suprareticulate; columellae indiscernible. Poles slightly but distinctly flattened (McAndrews et al. 1973, Faegri et al. 1989).

Lysimachia L.

Pollen grains determined according to Jørgensen's unpublished key. All grains tricolporate; distinctly per-reticulate.

Lysimachia nemorum L. – six pollen grains. Columellae scarcely visible. Lumina subequal, only occasionally decreasing towards the furrow.

Lysimachia nummularia L. (Pl. 1 fig. 12) – one pollen grain. Muri considerably thinner than in *Lysimachia vulgaris* type, made up of 1–2 rows of relatively large and prominent columellae. Lumina decreasing slightly towards the furrow, differing greatly in size.

Lysimachia thyrsiflora L. (Pl. 1 figs 13–14) – ten pollen grains. Columellae in muri hardly visible. Lumina distinctly decreasing towards the furrow.

Lysimachia vulgaris L. type (Pl. 1 figs 10–11) – three pollen grains. Reticulum with thick muri, clearly visible; columellae fine, arranged in 2–3 rows. Lumina very distinctly decreasing towards the furrow.

Nymphaea alba L. (Pl. 1 fig. 20) – thirteen pollen grains with very large, single and generally clearly visible pores, their opercula for the most part preserved. Grain surface covered with sculpture elements varying in shape and length – bacula, clavae, verrucae and even spines. Some elements even exceed 4 µm in length (Erdtman et al. 1961, Punt & Clarke 1981).

Nymphaea candida C. Presl. (Pl. 1 fig. 19) – sixteen pollen grains. Pores and opercula as in the preceding species. Grain surface covered with elements considerably more uniform in size and shape. Most of them very short and rather broad, bacula not present (Erdtman et al. 1961, Punt & Clarke 1981).

Plantago maritima L. s.l. – 21 pollen grains with distinct, broad annuli (Andersen 1961).

P. maritima L. s. str. – four pollen grains, without annuli.

Scleranthus annuus L. – one pollen grain with 18 pores surrounded by broad annuli. Columellae between pores very large and all of similar size, irregularly scattered (Erdtman et al. 1961).

Scleranthus perennis L. – one pollen grain with 12 pores with narrow annuli, surrounded by a belt of fine columellae. Columellae large, forming 2–3 distinct rows between pores on the grain surface (Andersen 1961, Erdtman et al. 1961).

Scrophularia L. type – two pollen grains, tricolporate, with obscurely visible pore, per-reticulate. Columellae easily visible, lumina slightly contracting towards the furrow (Moore et al. 1991).

Silene L. type (=*Silene*/*Arenaria* sensu Andersen 1961) – six pollen grains with 18–28 pores surrounded by narrow but well-defined annuli. Columellae homogeneous, but showing tendency to join in pairs.

Spergula arvensis L. type – two tricolpate pollen grains. Columellae on grain surface very distinct and fairly regularly distributed, absent in furrows. Perforations in tectum obscure (Faegri et al. 1989).

Stachys sylvatica L. type (Pl. 1 figs 17–18) – ten suprareticulate pollen grains with three straight well-defined furrows. Lumina differing little in size (Moore et al. 1991). All grains are of similar size, averaging 36×21 µm.

Viola arvensis Murray type – one stephanocolporate pollen grain, with four broad furrows. Surface fairly distinctly rugulate-verrucate, sculpture more clearly visible towards the poles. The grain, in equatorial view, presents an oval outline, slightly flattened at the poles (Moore et al. 1991).

ANALYSIS OF PLANT MACROFOSSILS

Pteridophyta

Salvinia natans (L) All. – all 123 macrosporangia and 383 macrospores typical and in a good state of preservation. Macrosporangia with black walls of clearly visible polygonal cells. Cream or white macrospores with mostly smooth walls and three characteristic valves in the top part.

Angiospermae

Betula nana L. – wingless nutlets identified on the basis of their shape (Białobrzeska & Truchanowiczówna 1960).

Aracites interglacialis Wieliczk. – nine well-preserved seeds, conforming well to the description of this species (Mamakowa & Velichkevich 1993a, b), were found in sediments from the Konieczki site. The seeds are variable in shape, obovate, elliptic to almost circular, tapering towards the base and have a small depression at the top. The differences in shape and size (1.7–2.2×1.3–1.5 mm) lie within the limits of variation quoted in the above-mentioned paper.

Aracites interglacialis is an extinct species, described for the first time by Velichkevich (1977b) and known so far from 11 sites of the Likhvinian (Alexandrian, Mazovian = Holstein) Interglacial from Belarus, Russia and the Ukraine. In Poland it has hitherto been identified from five sites: Olszewice, Stanowice, Nowiny Żukowskie, Maków Mazowiecki and Katowice (Mamakowa & Velichkevich 1993b).

At Konieczki, as at the sites above, the seeds of *Aracites interglacialis* occur in deposits formed in the younger part of the interglacial.

Nutlets of eight *Carex* species were identified from the Konieczki sediments, those of *Carex gracilis* and *C. rostrata* occurring in the largest numbers. Identifications were based on the characters given by Nilsson & Hjelmqvist (1967) and Berggren (1969).

Dulichium spathaceum Pers. – four fruits in a good state of preservation, elongate, 2.4–3.5×0.7–0.8 mm in size, bristles well preserved.

Eleocharis praemaximoviczii Dorof. – 171 fruits, trigonous, obovate, rounded and flattened at top, ending in a process. Fruits small, generally 0.8–1.0×0.5–0.7 mm, excluding process (Dorofeev 1986b).

E. praemaximoviczii is an extinct species. In shape and size its fruits most resemble those of *E. ovata* which grows in Poland today (Żukowski 1965). However, the fruits of *E. ovata* are somewhat smaller and are biconvex, not trigonous (Dorofeev 1986b).

Scirpus atroviroides Dorof. – 427 fruits were identified by Prof. F.Yu. Velichkevich. Fruits ellipsoidal or obovoid, very small. Species extinct, having occurred in the Pliocene and the first half of the Pleistocene. The contemporary species – *S. sylvaticus* has fruits very similar in form.

All the *Potamogeton* endocarps were determined by Prof. F.Yu. Velichkevich, who distinguished 17 species. Not all of them occur in Poland now, and some are extinct.

Potamogeton dorofeevii Wieliczk. – one endocarp. Species extinct, first distinguished by Velichkevich (1977a) in the deposits of the Likhvinian Interglacial in the Vitebsk region. It occurs in numerous interglacial and interstadial floras (Velichkevich 1982, 1990).

Potamogeton goretskyi Dorof. – one endocarp. Species extinct, first described by Dorofeev from the deposits of the Mazovian Interglacial at Zhidovshchizna (Dorofeev 1986a).

Potamogeton panormitanoides Dorof. – eleven endocarps of *P. panormitanoides* and eight defined as *P.* cf. *panormitanoides*. It is an extinct species, first described by Dorofeev from the deposits of the Likhvinian Interglacial at the Neznanovskye Viselki site. In form the endocarps of this species are very similar to those of *P. panormitanus* (Dorofeev 1986a).

Potamogeton cf. *sarjanensis* Wieliczk. – one endocarp. This is an extinct species, distinguished by Velichkevich (1979) from the deposits of the Likhvinian Interglacial in the Vitebsk region. It is thought to be characteristic of the Older Pleistocene (Velichkevich 1982). Nowadays, the Far Eastern species, *P. maackianus*, *P. oxyphyllus* and *P. malainus* of China and Japan have endocarps very similar in form (Velichkevich 1982, Dorofeev 1986a).

DESCRIPTION OF LOCAL POLLEN ASSEMBLAGE ZONES

The pollen diagram has been divided into local pollen assemblage zones – L PAZ. Within some of the zones subzones of pollen assemblages have been distinguished (Fig. 3).

Each zone is designated with the letter K (=Konieczki), a serial number, starting from the bottom upwards, and its name. The names of the zones and subzones are based on the most abundant or characteristic taxa. The boundaries of the zones and subzones were fixed to be in places where the pollen values of taxa of quantitative or indicative significance rose or fell.

K-1 *Betula* L PAZ (depth: 16.01–15.89 m; frequency: AP 132–204 grains/cm^2, NAP: 10–16 grains/cm^2).

This zone is represented by only two samples. The proportion of tree and shrub pollen is high (max. 92.8%). Very high pollen values of *Betula* undiff. (max. 68.6%) and a very low proportion of *Pinus sylvestris* type (21.8–28.5%) are characteristic features. The pollen values of *Juniperus* do not exceed 0.5%. *Hippophaë rhamnoides* was recorded from the bottom sample. The variety in taxa of herbaceous plants is meagre. The most abundant is Poaceae undiff. pollen (max. 5.2%), Cyperaceae pollen being less frequent.

The zone has no lower boundary, the upper one lies at the fall of the pollen value of *Betula* undiff. and the rise of *Pinus sylvestris* type.

K-2 *Pinus-Betula* L PAZ (depth: 15.89–15.46 m; frequency: AP 176–201 grains/cm^2, NAP 11–17 grains/cm^2).

The proportion of tree and shrub pollen is high (92.3–95.8%). The zone is characterized by a drop in the pollen values of *Betula* undiff. from 53.5 to 34.0% and a rise in the values of *Pinus sylvestris* type to 41.7%. In the upper part of the zone the proportion of *Alnus glutinosa* type rises to 9.5%, *Picea abies* to 7.6% and pollen of *Fraxinus* turns up at above 1%. There occur single pollen grains of *Populus tremula* type. Herbaceous plants are represented chiefly by Poaceae undiff. (up to 4.0%) and Cyperaceae (to 2.7%); in the younger part of the zone pollen grains of *Humulus lupulus* are numerous.

The upper boundary of the zone is marked by a drop in the value of *Pinus sylvestris* type and a rise in the pollen values of *Alnus glutinosa* type and *Betula* undiff.

The zone has been divided into two subzones: K-2a *Betula* and K-2b *Picea-Alnus*.

Characteristic of subzone K-2a *Betula* are the still high though decreasing pollen values of *Betula* undiff. The proportions of *Alnus glutinosa* type and *Picea abies* are below 1%.

Subzone K-2b *Picea-Alnus* is characterized by the increasing pollen values of *Alnus glutinosa* type and *Picea abies*, while the values of *Betula* undiff. decline.

K-3 *Betula-Alnus-Picea* L PAZ (depth: 15.46–15.12 m; frequency: AP 171–344 grains/cm^2, NAP 6–13 grains/cm^2).

The tree and shrub pollen proportion is 94.7–96.3%. The pollen values of *Betula* undiff. are again high (max. 47.8%) and accompanied by lower values of *Pinus sylvestris* type (14.4–24.0%). The values of *Alnus glutinosa* type grow to 23.1% and the proportion of *Fraxinus* (5.0%) is higher than in the preceding zone. The pollen of thermophilous broad-leaved trees rises above 1% for the first time: *Quercus* (to 1.8%), *Tilia cordata* type (to 1.8%), *Ulmus* (to 1.2%). The sporadic occurrence of the pollen of *Hedera helix*, *Cornus sanguinea*, *Sambucus racemosa*, *Frangula alnus* and *Viburnum* is recorded. *Humulus lupulus* pollen gives a continuous per mil curve.

The upper boundary of the zone is where the values of *Betula* undiff. drop and those of *Alnus glutinosa* type rise.

K-4 *Alnus-Picea-Fraxinus* L PAZ (depth: 15.12–14.28 m; frequency: AP 196–436 grains/cm^2, NAP 5–15 grains/cm^2).

The percentage of AP is 96.1–98.1%. *Alnus* *glutinosa* type has its highest values throughout the profile (max. 42.5%), and so have *Fraxinus* (max. 9.6%) and *Ulmus* (max. 2.0%). The pollen values of *Picea abies* (max. 16.5%), *Quercus* (max. 5.1%), *Tilia cordata* type (max. 2.7%) and *Corylus* (max. 5.0%) are higher than in the previous zone. Pollen grains of *Ilex aquifolium* type, *Hedera helix*, *Cornus sanguinea*, *Sambucus racemosa* and *Viburnum* are noted. *Humulus lupulus* has a continuous per mil curve and spores of *Osmunda regalis / O. claytoniana* turn up for the first time.

The zone has no upper boundary.

Remark! The top of the zone is in direct contact with the bottom of a disturbed layer (depth: 14.28–14.11 m; for description see p. 108). It may well be that the zone is incomplete here.

The zone has been divided into two subzones: K-4a *Fraxinus-Tilia* and K-4b *Betula-Pinus*.

Subzone K-4a *Fraxinus-Tilia* is distinguished by an almost continuous fall in the pollen value of *Betula* undiff. and a relatively high proportion of *Tilia cordata* type. The values of *Alnus glutinosa* type and *Fraxinus* are very high.

Subzone K-4b *Betula-Pinus* is characterized by an abrupt increase in *Betula* undiff. (max. 35.0%), accompanied by a slight rise in *Pinus sylvestris* type (max. 16.4%) and *Picea abies* (max. 16.5%). The pollen values of *Alnus glutinosa* type (22.8–30.2%) and *Quercus* (1.7–3.7%) are considerably lower than those found in the preceding subzone. In the top sample the proportion of *Taxus* exceeds 1%. There are microspores of *Isoëtes* cf. *lacustris* (max. 1.4%).

K-5 *Taxus-Alnus-Picea* L PAZ (depth: 14.11–12.13 m; frequency: AP very variable, 240–805 grains/cm^2, NAP 4–9 grains/cm^2).

The proportion of tree and shrub pollen is 97.0–99.6%. The very high pollen value of *Taxus* (max. 62.1%) and the relatively high values of *Alnus glutinosa* type (14.4–25.7%) and *Picea abies* (5.5–19.6%) are characteristic of this zone. The proportion of *Pinus sylvestris* type pollen is very low (5.1–16.2%). Pollen of *Ligustrum, Ilex aquifolium* type, *Hedera helix, Cornus sanguinea, Buxus, Vitis, Viscum, Viburnum* and *Sorbus* is present. Pollen of *Humulus lupulus* occurs almost constantly, that of *Stellaria holostea, Stachys sylvatica* type and *Impatiens* appears sporadically. There are spores of *Osmunda cinnamomea* and *O. regalis / O. claytoniana*.

The zone has no lower boundary, because it is in contact with the top of the disturbed layer; the upper boundary is placed at the decrease of the *Taxus* pollen values and the rise of the proportions of *Pinus sylvestris* type and *Betula* undiff.

The zone has been divided into two subzones: K-5a *Taxus* and K-5b *Carpinus-Quercus*. Subzone K-5a *Taxus* is notable for the highest pollen values of yew throughout the profile. They occur in the lower part of this subzone. In its top part the proportion of *Carpinus* exceeds 1%.

Subzone K-5b *Carpinus-Quercus* is characterized by a drop in the proportion of *Taxus* pollen to 10.6% at the top. The pollen values of *Quercus* and *Carpinus* increase (max. 10.2% and 7.8% respectively); pollen of *Abies* appears in the top part (max. 3.6%) and the proportion of *Picea abies* decreases. Pollen of *Trapa* and microsporangia of *Salvinia natans* are present.

K-6 *Carpinus-Pinus-Betula* L PAZ (depth: 12.13–11.53 m; frequency: AP 216–359 grains/cm^2, NAP 4–12 grains/cm^2).

The tree and shrub pollen constitutes 96.6–98.0%. The pollen values of *Pinus sylvestris* type (max. 29.5%) and *Betula* undiff. (max. 34.8%), higher than in the preceding zone, and a rise in the proportion of *Carpinus* and *Abies* are characteristic features of this zone. The percentage of *Taxus* is very low (1.1–6.8%).

The upper boundary of the zone is marked by a fall in the pollen value of *Pinus sylvestris* type and a rise in *Abies* and *Taxus*.

The zone has been divided into two subzones: K-6a *Betula* and K-6b *Abies-Picea*.

Subzone K-6a *Betula* is distinguished by a remarkable rise in the values of *Betula* undiff. and the relatively high values of *Pinus sylvestris* type. At the same time the proportions of *Alnus glutinosa* type, *Taxus, Carpinus, Quercus* and *Corylus* pollen all show a decrease.

Subzone K-6b *Abies-Picea* is characterized by a return to low values of *Betula* undiff., while the relatively high values of *Pinus sylvestris* type still persist. The proportion of *Picea abies* falls to 2.7% and those of *Abies* and *Carpinus* rise (to 11.2 and 18.3%, respectively) as does *Taxus* in the younger part of the subzone.

Fig. 3. Percentage pollen diagram from Konieczki. (Lithology: **1** – silt, **2** – sandy silt, **3** – gyttja, **4** – peat, **5** – sandy peat)

glutinosa type has its highest values throughout the profile (max. 42.5%), and so have *Fraxinus* (max. 9.6%) and *Ulmus* (max. 2.0%). The pollen values of *Picea abies* (max. 16.5%), *Quercus* (max. 5.1%), *Tilia cordata* type (max. 2.7%) and *Corylus* (max. 5.0%) are higher than in the previous zone. Pollen grains of *Ilex aquifolium* type, *Hedera helix*, *Cornus sanguinea*, *Sambucus racemosa* and *Viburnum* are noted. *Humulus lupulus* has a continuous per mil curve and spores of *Osmunda regalis / O. claytoniana* turn up for the first time.

The zone has no upper boundary.

Remark! The top of the zone is in direct contact with the bottom of a disturbed layer (depth: 14.28–14.11 m; for description see p. 108). It may well be that the zone is incomplete here.

The zone has been divided into two subzones: K-4a *Fraxinus-Tilia* and K-4b *Betula-Pinus*.

Subzone K-4a *Fraxinus-Tilia* is distinguished by an almost continuous fall in the pollen value of *Betula* undiff. and a relatively high proportion of *Tilia cordata* type. The values of *Alnus glutinosa* type and *Fraxinus* are very high.

Subzone K-4b *Betula-Pinus* is characterized by an abrupt increase in *Betula* undiff. (max. 35.0%), accompanied by a slight rise in *Pinus sylvestris* type (max. 16.4%) and *Picea abies* (max. 16.5%). The pollen values of *Alnus glutinosa* type (22.8–30.2%) and *Quercus* (1.7–3.7%) are considerably lower than those found in the preceding subzone. In the top sample the proportion of *Taxus* exceeds 1%. There are microspores of *Isoëtes* cf. *lacustris* (max. 1.4%).

K-5 *Taxus-Alnus-Picea* L PAZ (depth: 14.11–12.13 m; frequency: AP very variable, 240–805 grains/cm^2, NAP 4–9 grains/cm^2).

The proportion of tree and shrub pollen is 97.0–99.6%. The very high pollen value of *Taxus* (max. 62.1%) and the relatively high values of *Alnus glutinosa* type (14.4–25.7%) and *Picea abies* (5.5–19.6%) are characteristic of this zone. The proportion of *Pinus sylvestris* type pollen is very low (5.1–16.2%). Pollen of *Ligustrum*, *Ilex aquifolium* type, *Hedera helix*, *Cornus sanguinea*, *Buxus*, *Vitis*, *Viscum*, *Viburnum* and *Sorbus* is present. Pollen of *Humulus lupulus* occurs almost constantly, that of *Stellaria holostea*, *Stachys sylvatica* type and *Impatiens* appears sporadically. There are spores of *Osmunda cinnamomea* and *O. regalis / O. claytoniana*.

The zone has no lower boundary, because it is in contact with the top of the disturbed layer; the upper boundary is placed at the decrease of the *Taxus* pollen values and the rise of the proportions of *Pinus sylvestris* type and *Betula* undiff.

The zone has been divided into two subzones: K-5a *Taxus* and K-5b *Carpinus-Quercus*. Subzone K-5a *Taxus* is notable for the highest pollen values of yew throughout the profile. They occur in the lower part of this subzone. In its top part the proportion of *Carpinus* exceeds 1%.

Subzone K-5b *Carpinus-Quercus* is characterized by a drop in the proportion of *Taxus* pollen to 10.6% at the top. The pollen values of *Quercus* and *Carpinus* increase (max. 10.2% and 7.8% respectively); pollen of *Abies* appears in the top part (max. 3.6%) and the proportion of *Picea abies* decreases. Pollen of *Trapa* and microsporangia of *Salvinia natans* are present.

K-6 *Carpinus-Pinus-Betula* L PAZ (depth: 12.13–11.53 m; frequency: AP 216–359 grains/cm^2, NAP 4–12 grains/cm^2).

The tree and shrub pollen constitutes 96.6–98.0%. The pollen values of *Pinus sylvestris* type (max. 29.5%) and *Betula* undiff. (max. 34.8%), higher than in the preceding zone, and a rise in the proportion of *Carpinus* and *Abies* are characteristic features of this zone. The percentage of *Taxus* is very low (1.1–6.8%).

The upper boundary of the zone is marked by a fall in the pollen value of *Pinus sylvestris* type and a rise in *Abies* and *Taxus*.

The zone has been divided into two subzones: K-6a *Betula* and K-6b *Abies-Picea*.

Subzone K-6a *Betula* is distinguished by a remarkable rise in the values of *Betula* undiff. and the relatively high values of *Pinus sylvestris* type. At the same time the proportions of *Alnus glutinosa* type, *Taxus*, *Carpinus*, *Quercus* and *Corylus* pollen all show a decrease.

Subzone K-6b *Abies-Picea* is characterized by a return to low values of *Betula* undiff., while the relatively high values of *Pinus sylvestris* type still persist. The proportion of *Picea abies* falls to 2.7% and those of *Abies* and *Carpinus* rise (to 11.2 and 18.3%, respectively) as does *Taxus* in the younger part of the subzone.

K-7 *Carpinus-Abies-Alnus* L PAZ (depth: 11.53 –10.90 m; frequency: AP 134–394 grains/cm^2, NAP 3–6 grains/cm^2).

The proportion of tree and shrub pollen is 96.9–98.5%. Pollen of *Alnus glutinosa* type prevails; its values increase to 36.3% in the younger part of the zone as do those of *Carpinus* (to 19.1%) and *Abies* (to 19.2%). An abrupt change in the value of *Corylus*, from 3.9 to 16.7% takes place in the upper part of the zone. The proportion of *Picea abies* remains below 3.0%. Pollen of *Hedera helix*, *Cornus sanguinea, Buxus, Vitis* and *Viscum* is still present. The pollen of herbs, although represented by small numbers of grains, is relatively diversified. Noteworthy is the presence of *Stachys sylvatica* type, *Lysimachia vulgaris* type, *Symphytum* and *Lycopus*.

The upper boundary of the zone is placed at the fall in the pollen value of *Carpinus* and the resurgence in the proportion of *Taxus*.

K-8 *Abies-Taxus-Corylus* L PAZ (depth: 10.90 –10.12 m; frequency: AP 81–259 grains/cm^2, NAP 3–4 grains/cm^2).

The proportion of tree and shrub pollen is still very high and amounts to 96.2–98.9%. *Alnus glutinosa* type, *Abies, Taxus* and *Corylus* are dominant. *Vitis* and *Viburnum* have almost continuous per mil curves and the value of *Buxus* approaches 1%. Pollen of *Spergula arvensis* type, *Stachys sylvatica* type, *Bupleurum, Lysimachia thyrsiflora*, *Butomus umbellatus* and *Trapa* occurs sporadically. The microsporangia of *Salvinia natans* are not numerous but are constantly present.

The upper boundary of the zone is marked by a decrease in the pollen value of *Taxus*.

The zone has been divided into three subzones: K-8a *Taxus-Abies*, K-8b *Corylus-Quercus* and K-8c *Taxus-Carpinus*.

Subzone K-8a *Taxus-Abies* is distinguished by high values of *Taxus* (to 18.2%), *Abies* (to 20.3%) and *Alnus glutinosa* type (to 40.5%). The values of *Carpinus* are very low (1.9–4.2%)

Subzone K-8b *Corylus-Quercus* shows a rise in the proportion of *Corylus* to 22.0%, which is its highest value in the whole profile. The proportion of *Quercus* also rises, to 18.0%, and these changes are accompanied by a drop in the proportion of *Taxus* (21.0–8.9%) and *Abies* (11.7–6.4%).

Subzone K-8c *Taxus-Carpinus* is again characterized by high pollen values of *Taxus* (max. 16.3%) and *Abies* (max. 19.9%). *Carpinus* pollen also occurs in somewhat higher values (max. 7.5%), while the proportion of *Buxus* reaches 1.3%.

K-9 *Abies-Carpinus-Alnus* L PAZ (depth: 10.12 –7.75 m; frequency: AP 75–355 grains/cm^2, NAP 2–9 grains/cm^2).

Remark! At depths of 10.08–9.79 m and 9.34–9.16 m there are sediments which on the basis of the results of a pollen analysis are considered to be disturbed. The zone description given below does not take into account the results of the pollen analysis of the samples obtained from these disturbed layers (for description see p. 108).

The proportion of tree and shrub pollen is 95.7–98.2%. Dominant is the pollen of *Abies* (to 26.3%), *Alnus glutinosa* type (to 27.0%), and also *Carpinus* (to 14.8%) and *Quercus* (to 12.2%). The values of *Taxus* decrease towards the top of the zone (7.8–1.5%). Pollen of *Pterocarya* and *Celtis* appears and *Fagus* also occurs. Despite the low NAP values the diversity of herbaceous taxa is remarkable.

The upper boundary of the zone is marked by a fall in the proportions of *Quercus, Carpinus*, *Alnus glutinosa* type and also of *Abies* and *Picea abies* pollen and a rise in the values of *Pinus sylvestris* type.

The zone has been divided into two subzones: K-9a *Buxus-Vitis* and K-9b *Picea-Pterocarya*.

Subzone K-9a *Buxus-Vitis* shows a relatively high proportion of *Buxus* pollen (max. 1.9%). Single grains of *Vitis* are noted from its older part.

Subzone K-9b *Picea-Pterocarya* is characterized by a rise in the pollen value of *Picea abies* (10.4%) and the highest values of *Pterocarya* (2.5%) and Fagus (0.7%) throughout the profile.

K-10 *Pinus* L PAZ (depth: 7.75–7.40 m; frequency: AP 154–257 grains/cm^2, NAP 9–58 grains/cm^2).

The proportion of tree and shrub pollen decreases from 94.7% in the bottom sample of the zone to 72.0% in the top sample. The increasing pollen values of *Pinus sylvestris* type (39.3–49.0%) are a characteristic feature of the zone. A small rise is also visible in the proportion of *Betula* undiff. The values of *Alnus glutinosa* type (8.4–3.4%), *Quercus* (5.9–0.4%), *Carpinus* (4.9–0.6%), *Abies* (13.8–1.3%) and *Picea abies* (8.3–1.3%) decrease. A fairly rapid rise in the NAP values, caused mainly by Cyperaceae and Poaceae undiff., is observed in the younger part of the zone.

The upper boundary of the zone is placed at the fall of the pollen values of *Pinus sylvestris* type and the rise of NAP.

K-11 NAP-*Pinus-Betula* L PAZ (depth: 7.40–1.52 m; frequency: AP 53–177 grains/cm^2, NAP 33–68 grains/cm^2).

The proportion of tree and shrub pollen varies within the limits of 53.0–86.2%.

Remark! The comparatively high values of AP (71.2–86.2%), resulting from the higher proportion of pollen of *Alnus glutinosa* type, *Carpinus, Quercus, Picea abies* and *Abies*, recorded at a depth of 7.10–6.57 m, are due to the disturbances of sediments (for description see p. 109). In the description of the zone these values have not been taken into account.

The maximum proportion of AP outside the disturbed layer is 71.8%. Pollen of *Pinus sylvestris* type (26.4–45.4%) and *Betula* undiff. (to 28.3%) prevails. The proportion of *Picea abies* and *Abies* pollen is not high (max. 2.8 and 1.6% respectively). The curves of *Betula nana* (to 2.1%), *Larix* (to 1.9%), *Juniperus* (to 2.2%) and *Salix glauca* type (to 1.6%) are continuous. Pollen grains of *Hippophaë rhamnoides* are relatively frequent, while *Ephedra fragilis* type, *E. distachya* type and *E.* cf. *strobilacea* occur sporadically.

The zone has no upper boundary and has been divided into four subzones.

Subzone K-11a Cyperaceae-Poaceae exhibits high NAP values, mainly of Cyperaceae (max. 16.0%) and Poaceae undiff. (max. 14.2%). The proportion of *Betula* undiff. increases slightly (to 18.2%).

Subzone K-11b *Betula* is characterized by relatively high values of *Betula* undiff. (max. 28.3%).

Subzone K-11c Cyperaceae-*Betula nana-Juniperus* is characterized by the continuous occurrence of *Betula nana* pollen, which has appeared for the first time in its older part and the highest values of *Juniperus* throughout the profile.

Subzone K-11d Poaceae-*Artemisia* is distinguished by a small rise in the proportion of Poaceae undiff., *Artemisia* and *Betula nana* pollen.

DISTURBED LAYERS

In the pollen diagram from Konieczki there are sections in which the course of the pollen curves changes unexpectedly and abruptly. Such sharp deflections and abrupt changes in the values of AP, NAP or pollen of particular trees are not, generally, a result of climatic oscillations, but usually indicate some disturbances in the deposits.

The causes of these disturbances which have affected the pollen curves in the Konieczki diagram vary.

The first disturbed layer, 0.17 m thick, occurs above zone K-4 *Alnus-Picea-Fraxinus*, at a depth from 14.28–14.11 m. A high proportion of *Abies* and *Carpinus* pollen, whose values undergo sudden changes (*Abies* 2.3–16.6%, *Carpinus* 3.7–17.9%), is characteristic of it. At the same time there occur pollen grains of *Vitis, Buxus* and *Trapa* and microsporangia of *Salvinia natans*.

This layer extends below the beginning of the continuous curves of *Carpinus* and *Abies* and below the maximum values of *Taxus* pollen. In such a segment of the diagram pollen of *Abies* and *Carpinus* is not observed in other sites of the Mazovian Interglacial in Poland.

With the presence of *Buxus* and *Vitis* pollen and the absence of *Pterocarya* pollen, the sediments of this layer seem to have come from subzone K-9a *Buxus-Vitis* of zone K-9 *Abies-Carpinus-Alnus*; presumably, they broke off in the drilling process and slipped from the uncased walls of the borehole.

The second disturbed layer, 0.29 m thick, occurs inside zone K-9 *Abies-Carpinus-Alnus*, at a depth from 10.08–9.79 m. An analysis of the grain size distribution shows only small changes in fraction, but the organic matter content decreases distinctly.

There are very high pollen values of *Pinus sylvestris* type (max. 55.8%), *Betula* undiff. (max. 17.9%) and NAP (max. 32.5%), particularly Cyperaceae and Poaceae undiff., and a great variety of herbaceous taxa, alongside low pollen values of all thermophilous broad-leaved trees, *Abies* and *Taxus*. Also a nutlet of

Betula nana was found in the deposits of this layer. Such drastic fluctuations in the pollen values of trees with greater thermic requirements and the appearance of taxa representing cold periods, notably in this part of the interglacial succession, cannot be the result of natural processes. The percentage pollen values of particular taxa indicate that in the drilling process some sediments from zone K-11 NAP-*Pinus-Betula* broke off and slipped down the wall of the borehole.

The third disturbed layer, 0.18 m thick, lies at a depth from 9.34–9.16 m. Here occurs a rapid rise in the values of NAP (max. 10.8%), *Pinus sylvestris* type (max. 18.8%) and *Betula* undiff. (max. 8.9%). In all probability these pollen curve changes were also caused by the pulling down of deposits from zone K-11 at the time of drilling.

Of the foregoing layers, only the second is wholly composed of sediment derived from higher parts of the profile. In the remaining two layers, especially the third one, the sediment coming from above is mixed with that occurring in situ.

The fourth disturbed layer, 0.53 m thick, is present at a depth from 7.10 to 6.57 m within zone K-11. The genesis of these disturbances is, however, entirely different from the three layers discussed above. The pollen spectra of the fourth disturbed layer are characterized by a rise in the AP value (max. 86.2%) in comparison with the values occurring below and above this layer. The rise in AP is caused by the higher proportion of pollen of *Betula* undiff., *Alnus glutinosa* type, *Abies, Picea abies, Carpinus* and *Quercus*.

The higher pollen values of trees with greater thermic requirements may suggest a warm climatic swing. However, an analysis of the grain size distribution of the sediment makes it more likely that the changes observed are accounted for by redeposition. An increase in the proportion of the psammitic fraction in the deposit, reaching even 25% of the mineral composition, indicates a higher degree of erosion. The higher pollen values of thermophilous trees are undoubtedly the result of the outwashing of older sediments within the same body of water. The presence of *Pterocarya* and *Fagus* pollen suggests that the sediments were washed out of subzone K-9b *Picea-Pterocarya*. This cannot be responsible for the increase in the pollen values of *Betula* undiff., which probably arose from the colonizing of new habitats created as a result of the erosional processes.

Disturbances in pollen successions caused by redeposition within the same water bodies have been repeatedly described in the literature.

Mamakowa (1989) explains the rise in the pollen values of *Alnus* undiff., *Carpinus* and *Picea abies* in the period of cooling, shown in the diagram from Imbramowice, by just such erosional processes. She thinks that the so-called second climatic optimum in the Eemian Interglacial is also connected with such processes, e.g. at the Szwajcaria and Konopki Leśne sites (Borówko-Dłużakowa & Halicki 1957) or Sławno (Tołpa 1961).

Repeated abrupt changes in the pollen values of trees are recorded in the diagram from Poznań 1 (Winter 1991). In this case, too, the causes of the disturbances in the pollen succession are seen to be lithological changes occurring in the deposits in the process of sedimentation.

DESCRIPTION OF LOCAL MACROFOSSIL ASSEMBLAGE ZONES

The diagram of plant macrofossils has been divided into six local zones, designated with the letters KM (=Konieczki, macrofossils). The zones are numbered consecutively from the bottom to the top of the profile (Fig. 4).

KM-1 L MAZ (depth 16.01–8.70 m)

In this zone there are very few macrofossils, chiefly nutlets and fruit scales of *Betula pubescens*, *B.* cf. *pubescens*, *B.* cf. *pendula* and one nutlet of *B. nana* (outside the disturbed zone).

The upper boundary of the zone is placed below the sample in which the occurrence of *Potamogeton natans* endocarps begins.

KM-2 L MAZ (depth 8.70–7.73 m)

There are very numerous *Potamogeton natans* endocarps as well as macrosporangia and macrospores of *Salvinia natans*. Some fragmentary thorns and nuts of *Trapa* are noted. The fruits of *Eleocharis praemaximoviczii*, *Typha*, *Carex gracilis*, *C. elata*, *C. rostrata*, *C. pseudocyperus* and *C.* cf. *cespitosa* occur in the younger part of the zone. Also the seeds of *Aracites interglacialis* appear for the first time. The presence of one nutlet of *Betula nana* was recorded as well.

The upper boundary of the zone is immediately above the level where the occurrence of *Potamogeton natans* endocarps ceased.

KM-3 L MAZ (depth 7.73–6.64 m)

The zone is represented by the relatively heterogeneous remains of aquatic plants. The fruits of *Najas flexilis* are the most abundant, but the endocarps of *Potamogeton panormitanus*, *P. pusillus*, *P. praelongus*, *P. compressus* and others turn up also. The oospores of *Chara fragilis* appear for the first time. Comparatively abundant remains of reedswamp plants are noted. These are, just as in the preceding zone, *Carex gracilis*, *C. rostrata*, *C.* cf. *elata* and *C.* cf. *cespitosa*. The fruits of *Scirpus atroviroides*, *Ranunculus sceleratus*, *Typha*, *Eleocharis praemaximoviczii* and, in the younger part of the zone, also *E. palustris*/*E. mamillata* occur in large numbers.

There are few remains of *Betula nana,* the nutlets of *B.* cf. *humilis* appear for the first time and single macrospores of *Selaginella selaginoides* are present.

The upper boundary of the zone is marked by a fall in the number of *Najas flexilis* fruits.

KM-4 L MAZ (depth 6.64–3.14 m)

Fragments of needles of *Pinus cembra* are noted. The fruits and fruit scales of *Betula nana* are relatively abundant. Macrospores of *Selaginella selaginoides* occur in somewhat larger numbers than in the previous zone.

The fruits of *Callitriche autumnalis* are numerous, although they occur discontinuously. In the younger part of the zone the oospores of *Nitella opaca* are fairly abundant. Fruits of *Carex gracilis*, *C. rostrata, Eleocharis praemaximoviczii* and *E. palustris*/*E. mamillata* continue to be recorded. Some fruits of *Dulichium spathaceum* are present.

The upper boundary of the zone is placed below a sharp rise in the number of oospores of *Nitella opaca*.

KM-5 L MAZ (depth 3.14–2.67 m)

The variety of remains is small. The fruits of *Callitriche autumnalis* are present in masses, very numerous also are the oospores of *Nitella opaca*.

The upper boundary is fixed on the basis of the complete disappearance of the *Callitriche autumnalis* fruits.

KM-6 L MAZ (depth 2.67–1.52 m)

Macrofossils are very scarce. In the older part of the zone there are some – not numerous – oospores of *Nitella opaca*.

The zone is not bounded above.

CORRELATION

Eleven local pollen assemblage zones have been distinguished in the pollen succession from the Konieczki site. Zones K-1 – K-10 represent four pollen periods of the Mazovian Interglacial (Szafer 1953, Janczyk-Kopikowa 1987, 1991).

The lower boundary of the interglacial has not been established, because in the Konieczki profile the deposits corresponding to the older part of pollen period M I are missing. The upper boundary of the Mazovian Interglacial coincides with the upper boundary of zone K-10 *Pinus* (Tab. 3).

Zone K-11 NAP-*Pinus-Betula* represents the first cooling connected with the succeeding glaciation. This boundary was placed where the NAP values rise to above 30%, which indicates the thinning of the hitherto dense forest and the beginning of the development of open communities. The occurrence of *Betula nana* nutlets from the beginning of zone K-11 provides evidence of the development of tundra communities and the great variety of herbaceous taxa points to a remarkable diversity among the open communities. At the interglacial/glacial boundary there occurs a sediment change from peat to silt, accompanied by a very distinct fall in the organic matter content. The fresh increase in the organic matter content, observed in the older part of zone K-11, is for the most part probably the result of the development of peat-bog, but in part it may also be associated with the redeposition of allochthonous organic remains, which accompanied the increasing proportion of sand.

Fig. 4. Macrofossil diagram from Konieczki (**w** – wood, **fs** – fruit scales, **nf** – needles, **m** – macrospores, **ma** – macrosporangia; lithology as in Fig. 3)

Table 3. Division of the pollen succession from Konieczki into palynostratigraphic units and their correlation with the local macrofossil assemblage zones

Stage	Pollen period	Local pollen assemblage zones L PAZ		Local macrofossil assemblage zones L MAZ
EARLY GLACIAL		K-11 NAP-*Pinus-Betula*	d Poaceae-*Atemisia*	KM 6
				KM 5
			c Cyperaceae-*Betula nana -Juniperus*	KM 4
			b *Betula*	KM 3
			a Cyperaceae-Poaceae	
MAZOVIAN INTERGLACIAL	M IV	K-10 *Pinus*		
	M III	K-9 *Abies-Carpinus-Alnus*	b *Picea-Pterocarya*	KM 2
			a *Buxus-Vitis*	KM 1
		K-8 *Abies-Taxus-Corylus*	c *Taxus-Carpinus*	
			b *Corylus-Quercus*	
			a *Taxus-Abies*	
		K-7 *Carpinus-Abies-Alnus*		
		K-6 *Carpinus-Pinus-Betula*	b *Abies-Picea*	
			a *Betula*	
	M II	K-5 *Taxus-Alnus-Picea*	b *Carpinus-Quercus*	
			a *Taxus*	
		K-4 *Alnus-Picea-Fraxinus*	b *Betula-Pinus*	
			a *Fraxinus-Tilia*	
	M I	K-3 *Betula-Alnus-Picea*		
		K-2 *Pinus-Betula*	b *Picea-Alnus*	
			a *Betula*	
		K-1 *Betula*		

HISTORY OF THE VEGETATION

DEVELOPMENT OF TERRESTRIAL VEGETATION

The changes in the vegetation of the Konieczki region have been reconstructed on the basis of the local pollen assemblage zones, the results of the plant macrofossil analysis being taken into consideration as well.

Mazovian Interglacial

Pollen Period M I

K-1 *Betula* L PAZ. The history of the vegetation as recorded in the organogenic deposits from Konieczki started in the period when forest had already invaded this region and occupied the habitats earlier covered presumably by open communities. The high AP values, reaching 92.8%, indicate that these forest communities were dense. As regards the diversity of tree and shrub species, their composition was still very species poor. The prevailing proportion of *Betula* undiff. pollen (max. 68.6%) provides evidence of the leading role of birch in these communities and of its domination in many diverse habitats. The rather low pollen proportion of *Pinus sylvestris* type (21.8–28.5%) points to its small role in the forest communities of that time. It may be supposed, therefore, that in the proximity of the lake, there was mainly birch forest, varying in type, with only a small admixture of pine.

The identification of macrofossils as those of downy and silver birch (*Betula pubescens*, *B.* cf. *pubescens*, *B.* cf. *pendula*) shows that both these species grew in the lake region. Silver birch occupied dry sandy habitats and, together with the pine (*Pinus sylvestris* type) accompanying it, may have formed fairly open forest. *Juniperus* occurred in the meagre brushwood of this forest and various moss species grew for the most part in the herb layer (spores of Musci excl. *Sphagnum*). Herbs probably did not play a major role. Grasses (Poaceae undiff.), but probably only oligotrophic species, are likely to have formed a fairly high proportion of the vascular plants. *Rumex acetosella* (*R. acetosella* type) occurred sporadically.

Forest with a predominant proportion of *Betula pubescens,* and an admixture of *Pinus sylvestris* type, probably grew in moist habitats, especially in the neighbourhood of the lake, in the Pankówka valley and in the valleys of neighbouring streams. Mosses and grasses occurred in high proportions in the herb layer of such communities, but *Lycopodium annotinum* and *Thelypteris palustris* may have been present also.

The low proportion of NAP shows the minimal role played by herbaceous communities in the surroundings of Konieczki. The forest probably hugged the lake pretty closely, as is suggested by the presence of birch macrofossils. Only in the littoral zone itself were the moss-sedge communities still residually preserved, as is indicated by the relatively high values of Musci spores, the low values of Cyperaceae and the presence of *Thelypteris palustris*. The pollen of *Cirsium* perhaps comes from just such communities.

Although the dense forest did not leave much room for communities of open habitats, the presence of *Hippophaë rhamnoides* indicates that there still existed circumstances somewhere in proximity to the lake which permitted the continued growth of this light-demanding plant. It had persisted in isolated stands from an earlier period not represented in the deposits from Konieczki. Part of the Poaceae undiff. pollen and sporadic pollen grains of *Artemisia* and Chenopodiaceae can probably be referred to such communities as well.

K-2 *Pinus-Betula* L PAZ. The great increase in the pollen values of *Pinus sylvestris* type with the simultaneous drop in the values of *Betula* undiff., observed at the beginning of the zone, point to an abrupt rise in the significance of pine in the forest communities and its taking possession of the habitats previously occupied by birch. The decreasing proportion of Poaceae undiff. pollen indicates the encroachment of pine also on to the habitats occupied by grassy communities up to then.

In subzone K-2a *Betula* the proportion of birch in the forest communities was, however, still very great, as is indicated by the high pollen values of *Betula* undiff. (about 53%). Forest with a considerable proportion of downy birch still persisted but accompanied by a proportion of pine much higher than in the previous zone. The presence of downy birch in the close vicinity of the lake is confirmed by a fruit scale of *Betula pubescens*. The spores of *Lycopodium annotinum* and Musci (excl. *Sphagnum*) may be referred to the forest herb layer of these communities. Aspen (*Populus tremula* type) occurred sporadically and there was also spruce in the youngest part of subzone K-2a. *Frangula alnus* and *Juniperus* may have grown in the shrub layer, while *Calluna vulgaris* and various species of *Vaccinium* (*Vaccinium* type) occurred in the herb layer; *Rumex acetosella* (*R. acetosella* type), *Diphasiastrum complanatum* (*D. complanatum* type) and *Botrychium* were also present.

At the bottom of subzone K-2b *Picea-Alnus,* the pollen values of spruce rise above 4%, suggesting that this tree grew in the surroundings of the lake. A piece of wood identified as *Picea*/*Larix* may be additional evidence of its presence. It cannot be ruled out, however, that this piece of wood belongs to *Larix*, although this last species has low values of pollen here (0.5%). In the beginning, spruce formed a small admixture in the pine forest, chiefly in fresh and moist habitats, but also in developing alder-woods.

The continuous fall in the proportion of *Betula* undiff. pollen in subzone K-2b is indicative of a further reduction in the role of birch in the forest communities. The simultaneous increase in the pollen values of *Alnus glutinosa* type in this subzone suggests that in places alder entered the moist places previously occupied by downy birch. The remarkable continuous rise in the proportion of *Alnus glutinosa* type pollen may also indicate the spread of swampy habitats. It may be supposed that forest communities with a dominant proportion of alder were developing intensively, not just in the zone surrounding the lake, but also on the sides of the fairly extensive Pankówka valley. Certainly, they were communities which, in respect of their physiognomy and composition, resembled present-day wet alder-woods. *Alnus glutinosa* was the dominant tree and *Fraxinus* occurred as part of an admixture, completed by *Betula pubescens* and *Picea abies*. *Frangula alnus* occurred in the understorey, and the herb layer was made up, among other taxa, of *Scirpus atroviroides*, *Thelypteris palustris* and other ferns, *Humulus lupulus* and Cyperaceae.

Communities similar to today's riverine forest may have developed on the margins of wet alder-wood communities in the neighbourhood of the lake and in the stream valleys. All through subzone K-2b they existed as stands of alder and alder-ash communities with the addition of elm and perhaps also spruce and maple. However, the extent of these communities could not have been very great. Their herb layer may have included *Urtica dioica*, *Filipendula ulmaria* (*Filipendula* pollen), *Caltha palustris* (*Caltha* type) and also *Humulus lupulus* encountered in many types of damp forest. Mosses formed the ground cover and *Frangula alnus* grew in the brushwood.

The low pollen values of herbs (max. 7.7%) show that the lake region was covered with dense forest. The presence of a single pollen grain of *Ephedra fragilis* type suggests, however, that the conditions prevailing in some open pine and pine-birch communities could possibly have enabled some of the more light-loving plants to persist locally.

K-3 *Betula-Alnus-Picea* L PAZ. The resurgence in the pollen value of *Betula* undiff. provides evidence of a new expansion of birch in the forest communities. The small number of birch macrofossils makes interpretation of these changes difficult. It may, however, be inferred from the rapid decrease in the pollen values of *Pinus sylvestris* type, and the simultaneous rise of *Alnus glutinosa* type and *Fraxinus,* that the increase in birch occurred principally in the drier forest communities at the expense of pine. This is also indicated by the presence of single nutlets of *Betula* cf. *pendula*. And so in zone K-3 birch forest – again but only temporarily – dominated the forest landscape of the Konieczki region.

The rapid decrease in the pollen values of *Pinus sylvestris* type suggests that pine constituted merely an admixture in the forest surrounding the lake. It was only towards the top of the zone that its role in the forest communities again increased to a small extent. The simultaneous fall in the value of *Alnus glutinosa* type implies that this was probably associated with a small reduction in the development of the alder communities, which may have been caused by the temporary drying out of some of the habitats.

The overall marked rise in the pollen value of *Alnus glutinosa* type in zone K-3, however, confirms the tendency, general at that time, for forest with dominant alder to spread. Wet alder-woods were probably similar in their composition to those which had developed in the lake region in the preceding zone. *Viburnum* may also have been present in their understorey.

The constantly growing proportion of *Fraxinus* pollen (max. 5.0%) indicates the increasing significance of ash in the forest communities of moist and swampy habitats. Pollen values of *Fraxinus* of that order are regarded as high, because this taxon is never represented very abundantly in pollen spectra. Particularly favourable conditions for the development of communities with an admixture of ash may have existed in the Pankówka valley. These communities were supposedly alder-ash and alder-woods, in which, as in the previous zone, spruce may have occurred as well. Small-leaved lime (*Tilia cordata* type) possibly occurred in these forests, as did elm with its rather low proportion of pollen in this zone. However, it cannot be entirely ruled out that there were also small patches of ash-elm woods in the more fertile habitats. Their stands probably included, in addition to *Fraxinus* and *Ulmus*, *Quercus*, more rarely *Alnus glutinosa* (*A. glutinosa* type), *Acer, Populus* (*P. tremula* type) and *Tilia cordata* (*T. cordata* type).

The pollen findings show that the understorey of the riverine communities was becoming more varied; *Frangula alnus*, *Sambucus racemosa* and *Cornus sanguinea* were present in it. *Urtica dioica* (1 fruit), *Humulus lupulus*, *Filipendula* and perhaps also *Cirsium* grew in the herb layer.

The pollen values of *Picea abies* (max. 7.0%) and *Pinus sylvestris* type (14.4–24.0%) suggest that in zone K-3 stands of pine-spruce communities containing downy birch, sporadic aspen (*Populus tremula* type) and oak were being formed in this region. The shrub layer consisted presumably, among other taxa, of *Frangula alnus*, *Juniperus* and, sporadically, *Corylus*. *Lycopodium annotinum*, *Pteridium aquilinum*, *Calluna vulgaris* and *Vaccinium* (*Vaccinium* type) occurred in the herb layer.

Pollen Period M II

K-4 *Alnus-Picea-Fraxinus* L PAZ. The highest pollen values of *Alnus glutinosa* type (42.5%), *Fraxinus* (9.6%) and *Ulmus* (2.0%) in the whole profile prove that alder, alder-ash and elm-ash forests reached their maximum expansion here. Such a high proportion of pollen of these trees indicates the abundance of wet habitats in the period represented by zoneK-4.

The changes which took place in the forest communities containing alder, both in wet alder-wood and in riverine communities, concerned chiefly the increase in the role of ash, for this taxon is considered to be under-represented in pollen assemblages (Andersen 1970, 1973, Mamakowa 1989). And so its role in the forest communities must have been considerably greater than that suggested by the percentage values of its pollen. The maximum values of *Humulus lupulus* pollen (1.2%) and the presence of spores of *Osmunda regalis*/*O. claytoniana* should be ascribed to communities of this type.

Also the riverine forest, chiefly of alder and ash, spread more widely. The higher pollen values of *Ulmus* may indicate a development of elm-ash communities, some small stands of which had existed as early as the decline of zone K-3. In addition to elm and ash, they probably also included alder, oak, maple and sporadic poplar. *Cornus sanguinea* and *Frangula alnus* were still growing, among other species, in the forest understorey.

In subzone K-4a *Fraxinus-Tilia*, the frequency of birch in the forest communities was steadily falling. Pine, which occurred as a small admixture in the forest communities of varied type in the Konieczki region, also played a minor role.

The increasing proportion of *Quercus* and *Picea abies* pollen in the younger part of subzone K-4a perhaps means the onset of changes in the coniferous forest leading to its transformation to mixed spruce-oak forest. In addition to the dominant spruce, and constant admixture of oak, there probably occurred some birch, pine and, sporadically, aspen (*Populus tremula* type) in this forest. *Lycopodium annotinum, Huperzia selago, Pteridium aquilinum*, numerous dwarf shrubs, such as *Calluna vulgaris* and *Vaccinium* (*Vaccinium* type) grew in the herb layer.

The highest pollen values of *Tilia cordata* type (max. 2.7%), the relatively frequent pollen grains of *Acer* and sporadic grains of *Tilia platyphyllos* type, indicate that stands of multispecies forest with lime, maple and elm may have come into existence on the fairly steep slopes of the neighbouring hills. Pollen of *Campanula* perhaps comes from the herb layer of this type of community on the slopes.

A rapid growth in the pollen values of *Betula* undiff. took place in subzone K-4b *Betula-Pinus*. The fall in the pollen proportion of *Alnus glutinosa* type and *Fraxinus* proves that the development of birch forest proceeded mainly at the expense of alder and alder-ash communities. The small increase in the pollen values of *Picea abies* shows that mixed coniferous forest with dominant spruce and an admixture of oak may have gained slightly in importance.

An analysis of the vegetational changes in the surroundings of the lake during the decline of zone K-4 seems to indicate that a resurgence of birch forest followed a sudden reduction in the occurrence of wet habitats. This possibly happened as a result of local changes in the water table responsible for the drying up of some areas. These habitats were soon invaded by birch, which occupied both moist and somewhat drier habitats (nutlets of *Betula* cf. *pubescens*, *B.* cf. *pendula*).

However, it cannot be completely ruled out that the expansion of birch was caused by a short-lived climatic cooling.

K-5 *Taxus-Alnus-Picea* L PAZ. In zone K-5 the forest communities of the Konieczki region underwent a fundamental transformation associated with the vast expansion of yew. This is indicated by the exceptionally high pollen values of *Taxus* (to 62.1%). Owing to disturbance of the deposits it is hard to fix unequivocally the beginning of the encroachment of yew upon the forest communities. However, its expansion was probably quite rapid and involved a diversity of habitats. The abrupt development of birch forest towards the end of the previous zone seems to have made it easier for yew to invade new habitats. Yew, which generally loses out in competition with other trees, was able to overcome birch comparatively easily. The fall in the pollen values of *Alnus glutinosa* type suggests that yew also occupied some drier alder habitats. The expansion of *Taxus* only very slightly restricted the extent of spruce and spruce-oak communities.

The very high pollen values of *Taxus*, particularly in the lower part of the zone, point to highly favourable microclimatic and soil conditions for this species in the lake region at Konieczki. Such a great expansion of yew was also possible owing to its wide ecological tolerance and ability to become acclimatized to local environmental conditions, as has been emphasized by Król (1975). These attributes enable yew to grow in various soils and lighting conditions at the present time. It is generally assumed that yew is a tree which tolerates very deep shade and so it finds good conditions for development under the canopy of other trees (Bugała 1975). According to Traczyk (1953) strong light is not harmful to it in good soil conditions.

An analysis of its present occurrence shows that yew grows in very varied forest communities. A number of yew ecotypes have even been distinguished from their adaptation to definite plant associations (Król 1975). Yew is very rarely come across in the present-day forest of the Woźniki-Wieluń Upland and its immediate surroundings but, this notwithstanding, it is a constituent of various forest communities. Its presence in alder-woods is exemplified by the "Cisy w Łebkach" reserve. In the "Cisy nad Liswartą" reserve it grows in mixed deciduous forest and in alder-ash riverine forest (Czartoryski 1975, Król 1975).

On the basis of its present-day distribution it may be assumed that yew contributed to the composition of various forest communities in the Mazovian Interglacial as well. In the lake region it accompanied alder in swamp habitats occupied by wet alder-woods and may have formed an admixture in riverine forest communities too. Presumably, it also occurred in mixed deciduous forest.

However, the exceptionally high pollen values of *Taxus* at Konieczki mean that the role of this tree could not have been restricted to that of an admixture in other forest communities. It seems probable that in the lake surroundings yew, at least in the initial period of its domination, formed autonomous yew woods, or woods with its distinct prevalence. And so, at that time, it grew in full light, free from the cover of the higher forest layer, probably in rather moist and fertile habitats. It is pollen delivery from communities of this type that is mainly responsible for its very high values in subzone K-5a *Taxus*.

The feasibility of the formation of autonomous yew forest in the Mazovian Interglacial is borne out by instances today of stands composed exclusively or predominantly of this species. In Poland an example of the autonomous occurrence of yew trees (about 200 in number) is found in the Przybynów region (Częstochowa Province), where they have grown up in a pasture left after the clearance of a wood (Król 1975, after Pfabe 1950). There was also a yew wood on the Sussex-Hampshire border in England; it came into existence after the cutting down of a beech-wood with yew undergrowth (Król 1975 after Tansley 1911). This wood in England was characterized by so close a cover of trees, and such shade, that it became impenetrable to other tree species.

Alder communities, which reached their highest state of development in the previous zone, were no longer of such great importance in zone K-5, but their proportion was still high. The appearance of *Osmunda cinnamomea* spores, and the occurrence of *O. regalis*/*O. claytoniana* and *Thelypteris palustris,* point to their rich fern cover.

Ash-alder and alder communities, probably with the presence of spruce, oak and, sporadically, elm, still occurred in riverine habitats. The appearance of pollen of *Vitis, Sambucus nigra, Impatiens* and *Stachys sylvatica* type is probably associated with these types of forest community.

During the course of the period corresponding to subzone K-5a, mixed coniferous forest with dominant spruce somewhat declined in importance. Oak was still an essential constituent, while aspen (pollen of *Populus tremula* type) and *Sorbus* may have occurred sporadically. *Frangula alnus* and *Juniperus* presumably grew in the shrub layer and *Huperzia selago*, *Lycopodium annotinum*, *Equisetum* and various species of *Vaccinium*, among other taxa, in the herb layer.

The presence of a single nutlet of *Betula nana* noted towards the top of subzone K-5a implies that, in spite of the mild climate and the domination of dense forest communities, this plant survived, probably somewhere in the immediate neighbourhood of the lake. Some instances of the presence of dwarf birch in the optimal periods of the interglacial as a relict from the cool glacial period have been mentioned by Tołpa (1952) and Noryśkiewicz (1978). Nowadays such relict sites of *Betula nana* occur in Poland in Pomerania (Linie near Chełmno), the Izara Mts and the Duszniki region (Szafer et al. 1976).

In subzone K-5b *Carpinus-Quercus,* the distribution of yew was being continuously restricted. The successive fall in the proportion of its pollen, with the simultaneous rise in the values of *Carpinus, Quercus, Picea abies, Pinus sylvestris* type and also of *Betula* undiff. and *Corylus*, points distinctly to a transformation of the various communities from which it was being displaced. The habitats previously occupied by yew fell gradually to oak, hornbeam and spruce. The increasing pollen values of *Pinus sylvestris* type show that pine, too, began to turn up more abundantly in forest communities, probably invading the poorer habitats. Small stands of mixed pine-oak woods with small-leaved lime (*Tilia cordata* type) and *Larix* probably began to develop. In spite of very low pollen values, the presence of larch in the forest communities of that period is, demonstrated by the presence of fragments of its needles.

The rise in the proportion of *Carpinus* pollen (max. 7.8%) in subzone K-5b signals the beginning of the development of oak-hornbeam forest. The fairly high pollen values of *Tilia cordata* type and the frequent, though single, occurrence of *Acer* pollen grains in samples suggests an admixture of small-leaved lime and maple in these communities. This rich mixed forest no doubt grew in moist and fertile habitats on the postglacial plateau. Its composition and habitat requirements probably brought it close to the oak-hornbeam forest growing in the area at the present time. Its undergrowth abounded in hazel, which, in addition to hornbeam, may have been ousting yew rather strenuously. The diversified layer of undergrowth was composed, in addition to *Corylus*, of *Hedera helix*, *Ligustrum*, *Viburnum*, *Sambucus nigra*, *S. racemosa*, *Ilex aquifolium* and *Buxus*, whose pollen is fairly frequent in this subzone. The presence of *Ilex aquifolium* type and *Buxus* pollen (most probably *B. sempervirens*) is noteworthy because these shrubs do not grow in the wild in Poland today. The herb layer may have included *Stellaria holostea* and *Impatiens*, whose pollen was noted only in this subzone.

The proportion of *Abies* pollen increases towards the top of the zone, which suggests that fir appeared in the surroundings of the lake. Its role in the formation of communities was still small, probably occurring only as a slight admixture in deciduous forest. However, the appearance of fir started a new stage in the history of the forest.

Pollen period M III

K-6 *Carpinus-Pinus-Betula* L PAZ. The rapid increase in the pollen values of *Betula* undiff. and *Pinus sylvestris* type, and the parallel fall in the pollen of all the trees playing a material role in the preceding zone, seem to indicate some very essential and unexpected changes in the forest communities of the Konieczki region. Such sudden changes always give rise to suspicions that the deposits have been in some way disturbed. However, the results of an analysis of the pollen spectra from zone K-6 rule out this possibility. The removal of sediment from the upper part of the profile would have had to have produced pollen spectra with a high proportion of herbaceous pollen, which is not observed here. Nor does it seem likely that zone K-6 could have arisen as the result of the washing and redeposition of older sediments formed in the initial part of the interglacial. This is effectively ruled out by the analysis of the grain size distribution of the sediments which shows no changes in its mineral composition.

Recognition that the above-mentioned changes in the pollen spectra are reflections of changes in the plant succession leads us to conclude that, in the Konieczki region, birch-pine forest spread during the period of climatic optimum. The presence of both species of tree birch in the direct vicinity of the lake is clearly shown by the presence of nutlets of *Betula* cf. *pendula* and a fruit scale of *Betula pubescens*.

After a short-lived dominance of birch, pine and pine-spruce forest with a small admixture of oak and larch became prevalent in the landscape of the lake area. Fragments of *Larix* needles found in the deposit point to the presence of larch.

The relative fall in the pollen value of *Alnus glutinosa* type and the total disappearance of *Fraxinus* indicate the reduced significance of riverine communities. In swampy habitats the wet alder-woods, with an admixture of ash, downy birch and spruce, persisted, but with a much smaller role than in zone K-5.

After the rather short period of absolute dominance of birch and pine, the thermophilous deciduous trees again began to gain in importance, as is proved by the rise in their pollen values in subzone K-6b *Abies-Picea*.

The steep rise in the proportion of *Carpinus* pollen and the increase in the *Abies* values in subzone K-6b provide evidence of the spread of hornbeam and fir in the Konieczki region. Fir, to be sure, had already entered the multi-species communities of oak-hornbeam forest which grew in fertile habitats. In consequence, towards the top of zone K-6, deciduous forest with a remarkable proportion of fir, probably, resembling present-day hornbeam-oak community was dominant in the landscape. Stands of these communities may have been characterized by considerable differentiation. Hornbeam-fir forest was probably particularly widespread, but oak-hornbeam communities may have persisted as well. The ascending pollen values of *Tilia cordata* type suggest that small-leaved lime was quite numerous in hornbeam-oak communities. Spruce, pine and, in moister places also alder, perhaps occurred in them. The oak-hornbeam communities with an appreciable admixture of small-leaved lime created favourable conditions for holly (*Ilex aquifolium* type). The pollen values of *Taxus*, increasing again in the younger part of the zone, indicate a greater proportion of yew in the hornbeam-oak communities. The undergrowth was made up of shrubs of *Corylus*, *Frangula alnus*, *Hedera helix*, *Ligustrum*, *Buxus* and *Viburnum* whose abundance continued.

Starting from the bottom of subzone K-6b the spruce forest slowly began to retreat from the Konieczki region, and pine, too, was on the decrease. These changes were caused by the expansion of hornbeam and fir and also the return of yew to the lake surroundings. The rise in the proportion of *Alnus glutinosa* type pollen shows that alder communities were developing afresh.

Having studied the changes in zone K-6, we should ask why they came about. Lack of charcoal dust in the deposits rather rules out the supposition that they were caused by fire. It could be suggested here that the expansion of birch and pine was due to local hydrological factors, but it seems more likely that the profile from Konieczki provides further proof of a cool oscillation in the climatic optimum of this interglacial. Krupiński (1988) and Krupiński & Lindner (1991) noted a similar rise in the significance of pine after a period of maximum yew development in sites in north-eastern Poland, referring it to a slight climatic desiccation. That rise was greater than the one observed at Konieczki, but the role of pine in the forest communities of the Biała Podlaska region was greater to begin with. Recently, Bińka (1995) recorded a similar phenomenon from the Woskrzenice profile in Podlasie. In other localities of the Mazovian Interglacial a small increase in the pollen values of *Pinus* is visible in diagrams from Ciechanki Krzesimowskie (Brem 1953) and Syrniki on the River Wieprz (Sobolewska 1956a).

K-7 *Carpinus-Abies-Alnus* L PAZ. The high pollen values of *Abies* and *Carpinus* (to 19.2 and 19.1%, respectively) demonstrate the great importance of fir and hornbeam in the forest communities. Fir-hornbeam and hornbeam-fir forests, with a constant admixture of oak, were dominant in the landscape throughout zone K-7. The increasing proportion of *Taxus* pollen in the older part of this zone indicates another expansion of yew.

The rise in the pollen values of *Tilia cordata* type points to considerable frequency of lime in hornbeam forest. Pollen of *Acer* and *Ulmus* as well as *Buxus*, *Hedera helix* and *Viscum,* is also very likely to have been associated with these forests.

The rise in the pollen values of *Alnus glutinosa* type, which had already begun in the preceding zone, shows that the proportion of communities with dominant alder was again very great at this time. The values of its pollen, similar to those which had occurred in zone K-4, show that it was again taking over new habitats. The distinct correlation between the increase in the pollen value of *Alnus glutinosa* type and the decrease of *Taxus* values in the younger part of the zone indicates that alder may have developed at the expense of the yew which had been growing in swampy habitats.

The low proportion of *Fraxinus* pollen possibly points to a considerable reduction in the extent of alder-ash riverine communities. That such communities were present in the lake region, however, is shown by the large number of taxa whose pollen may be referred to riverine habitats. These are, above all, *Lycopus*, *Urtica dioica*, *Lysimachia vulgaris* (*L. vulgaris* type) and *Stachys sylvatica* (*S. sylvatica* type).

K-8 *Abies-Taxus-Corylus* L PAZ. The fall in the pollen values of *Carpinus* to 1.9% points to a radical reduction in the amount of hornbeam contained in forest communities. The retreat of *Carpinus* from the Konieczki area was sudden and probably attributable to the fairly intense re-expansion of yew, which was replacing hornbeam in fir-hornbeam forest. The increase in the pollen values of *Corylus*, and the increasingly frequent occurrence of *Buxus* pollen, indicate the greater abundance of these taxa in the forest undergrowth. *Viburnum*, *Ligustrum*, *Hedera helix* and, in the canopy, *Viscum*, may have been present here as well.

The low pollen values of *Pinus sylvestris* type (7.1–9.9%) demonstrate the small role of pine in the Konieczki region forest at this time. Its presence near the lake is, however, confirmed by cone scales (cf. *Pinus*). Like pine, spruce played a minor role, growing only as an admixture in hornbeam and alder communities.

A rapid but transitory rise in the pollen values of *Alnus glutinosa* type (40.5%) is observed in the bottom part of subzone K-8a *Taxus-Abies*. The pollen values of *Alnus glutinosa* type, consistently in the range 21.7–31.0% in the remaining part of this subzone, show that wet alder- woods and alder riverine forests with a small admixture of ash and elm were still significant. The almost continuous per mil curve of *Vitis* represents the constant presence of vine in their undergrowth.

The rapid increase in the pollen values of *Corylus*, which took place in subzone K-8b *Corylus-Quercus*, is distinctly correlated with the fall in the pollen values of *Abies* and *Taxus*. This may suggest that the spread of hazel proceeded at the expense of both of these genera. It is hard to establish unequivocally what could have caused such drastic upheavals within these communities. Such changes would seem to have been brought about by the drying out of some habitats. This conclusion is also supported by the next change observed in the subzone, i.e. an increase in the pollen value of *Quercus*, indicating an intense expansion of oak, probably also on to drier habitats. The direct effect of this expansion was a great reduction in the occurrence of hazel. Stands of dry, thermophilous open oak forest presumably came into existence at that time. However, they lasted for only a short time, as is indicated by a fall in the pollen value of *Quercus* at the beginning of the next subzone, K-8c *Taxus-Carpinus*.

The simultaneous continuous increase in the pollen values of *Abies* and *Taxus* in subzone K-8c proves that, for both these genera, the process of regaining their former importance was in progress. The fir-yew communities, probably with a constant admixture of oak, once more flourished in the lake surroundings. That was, however, the very last period of the abundance of yew in the Konieczki region. The constant decrease in the pollen values of *Taxus* in the younger part of this subzone suggests that, from being a main constituent of forest communities, yew became an admixture only, supposedly mainly in the communities of mixed forest with fir.

The slight rise in the pollen values of *Carpinus* towards the top of this subzone shows a recurring small increase in the frequency of hornbeam in the forest of the lake area.

The frequent occurrence of pollen grains of *Buxus*, *Viburnum* and *Frangula alnus*, sporadic presence of *Hedera helix*, *Sambucus racemosa* and *Ligustrum* in subzones K-8b and K-8c indicates that the undergrowth of the hornbeam forest and open oak forest was just as rich as in subzone K-8a.

K-9 *Abies-Carpinus-Alnus* L PAZ. Zone K-9 is disturbed two times. The first disturbance is caused by a deposit layer pulled down from the upper part of the profile at the time of drilling. It is visible directly above the changes signalling a successive very essential reconstruction of the forest communities, that is, above the increase in the pollen values of *Abies* and *Carpinus*. These changes continue just above the pulled-down deposit layer. A further disturbance occurred at depths between 9.34 and 9.16 m. On this occasion the fallen deposit was undoubtedly a small lump of sediment, which mingled with the deposits occurring naturally at this depth and for this reason the disturbance was not so drastic as that at the beginning of the zone. Despite these two disturbances the nature of zone K-9 is very distinct.

The highest pollen values of *Abies* in the whole profile and the repeated high values of *Carpinus* reflect the very high proportion of fir and hornbeam in forest communities. The still rather high pollen values of *Quercus*, *Taxus* and *Corylus* noted throughout the zone indicate that the proportion of these trees in the Konieczki area forest was fairly great. These findings enable us to assume that mixed multispecies forest with a high proportion of fir, and fir forest played very important roles at that time. Hornbeam-oak communities with a pretty large admixture of *Abies* also extended their range again. Small-leaved lime in all probability occurred sporadically, because only single pollen grains of *Tilia cordata* type were observed in several samples.

Noteworthy is the still very rich composition of the forest undergrowth, in which *Buxus* constituted a particularly high proportion, as shown by the continuous curve of its pollen (up to 1.9%). *Frangula alnus* and *Viburnum* were frequent and *Hedera helix*, *Ligustrum* and *Vitis* less abundant. *Euonymus* also appeared in the younger part of the zone. Pollen of *Lysimachia nemorum*, *Anemone* type, *Scrophularia* type and *Mercurialis* cf. *perennis* most probably has its source in the herb layer.

In subzone K-9a *Buxus-Vitis*, the alder communities were probably fairly stable and of a similar nature to those represented in zone K-8. Some small but characteristic changes took place in them in the youngest part of the zone, in subzone K-9b *Picea-Pterocarya,* for it is in these communities that in all probability *Pterocarya* (max. 2.5%) and *Celtis*, represented by single pollen grains, appeared. The occurrence of *Pterocarya* in this part of the Mazovian Interglacial is reported from many sites (Stachurska 1957, 1961, Sobolewska 1975, Borówko-Dłużakowa & Słowański 1991, Krupiński & Nitychoruk 1991, Laskowska-Wysoczańska & Oszast 1990 and others), whereas *Celtis* is recorded less frequently.

Another essential characteristic of subzone K-9b is the occurrence of *Fagus* pollen, illustrated by its continuous per mil curve (max. 0.7%). Previously, only single grains were noted, albeit on several occasions. It is pertinent ask whether beech really did occur sporadically in the forest communities of the Mazovian Interglacial or whether its pollen was deposited by the wind or redeposited. Środoń (1985, 1990) claims that, in Pleistocene deposits, *Fagus* pollen was derived exclusively from Tertiary redeposition. In the deposits of subzone K-9b at Konieczki, except for those of *Pterocarya* and *Celtis*, not even single pollen grains have been noted which could be referred to redeposition. Neither does an analysis of the deposits increase the probability that some older sediments were redeposited, for in subzone K-9b there is a rise in the organic matter content associated with the beginning of the laying down of peat (Fig. 3). The drifting of *Fagus* pollen cannot be totally ruled out, but it is hardly possible given the presence of very dense forest communities, the evidence for which is provided by the proportion of tree and shrub pollen, lying within limits of 95.7–98.2%. It seems, therefore, that the possibility of the arrival of beech in the Woźniki-Wieluń Upland and its presence as scattered trees in the forest surrounding the lake must be accepted. In Niklewski's (1968) opinion, in spite of only a sporadic occurrence of *Fagus* pollen in the Eemian deposits from Główczyn, the possibility of the presence of this tree in the Eemian Interglacial cannot be entirely denied. Neither does Beug (1973) rule out the possibility of its occurrence in the Eemian Interglacial, in spite of the scarcely sporadic presence of grains of *Fagus* in the deposits at Zeifen.

The fall in the pollen values of *Alnus glutinosa* type, observed in the top part of subzone K-9a and persisting in subzone K-9b, implies a decrease in the role of alder communities. The simultaneous rise in the proportion of *Picea abies* pollen and, in the younger part of subzone K-9b, the rapid rise in *Pinus sylvestris* type, show that the habitats vacated by alder-woods became occupied by pine and spruce communities, accompanied by downy birch (nutlets of *Betula* cf. *pubescens*). *Frangula alnus* may have been growing in the undergrowth of this forest. The occurrence of single fruits of *Andromeda polifolia* and *Chamaedaphne calyculata* towards the top of the subzone points to the development of peat-bogs, perhaps raised ones, in the vicinity of the lake.

The decrease in the pollen value of *Quercus*, found in the younger part of subzone K-9b and, somewhat later, the fall in the pollen of *Carpinus, Taxus* and *Abies*, indicating the retreat of hornbeam and fir-hornbeam communities from the Konieczki region, are a sign of the worsening of the climatic conditions.

In spite of the gradual transformations which took place in the forest communities owing to the worsening climate, the forest in the Konieczki neighbourhood remained dense.

Pollen Period M IV

K-10 *Pinus* L PAZ. The fall in the pollen values of trees and shrubs from 94.7 % in the bottom part of zone K-10 to 72.0% at the top, points to some very important and violent changes which were occurring in the plant communities of the Konieczki region. Very dense forest which was still growing at the beginning of the zone was undergoing a gradual thinning, while the newly created habitats vacated were invaded by communities of herbaceous plants.

The fall in the pollen values of *Quercus* and *Carpinus* to about 0.5% suggests that towards the end of zone K-10 these trees no longer grew in the area of the lake. The low pollen proportion of *Abies* and *Picea abies* probably indicates that fir and spruce were present, but only in small numbers. The constant drop in the pollen values of *Alnus glutinosa* type proves that the significance of alder communities was being consistently diminished. *Pterocarya* was still growing in communities of this type.

It was mainly pine that initially spread in the habitats left by the retreating hornbeam and fir-hornbeam communities, as is reflected by a rise in the pollen values of *Pinus sylvestris* type, reaching a maximum of 49.0%. An increase in the values of *Betula* undiff. pollen and the relatively high values of *Larix*, indicate a higher proportion of tree birches than existed towards the top of the previous zone and the frequent occurrence of larch in the forest communities. It may be supposed that pine occupied also some wet habitats and formed marsh coniferous forest with some proportion of downy birch (nutlet of *Betula* cf. *pubescens*) and *Sphagnum* in the herb layer.

A rise in the NAP value reflects the development of herbaceous communities, which, under worsening climatic conditions, were in a position to occupy the new habitats resulting from the thinning of what not long before had been dense forest. The rather high proportion of Poaceae undiff. pollen points to the considerable spread of grass communities with, presumably, an abundance of *Artemisia* in dry habitats. As is suggested by the fairly high proportion of Cyperaceae pollen and Musci spores, sedge-moss communities may have been developing in the surroundings of the lake and also in habitats previously occupied by alder-woods. A great diversity of herbaceous taxa in the top part of zone K-10 indicates the formation of various open communities.

Early Glacial

K-11 NAP-*Pinus-Betula* L PAZ. The interpretation of the changes in vegetation occurring in zone K-11 is confronted with difficulties connected with the disturbance of sediments in subzone K-11b *Betula* (see p. 109).

A general tendency throughout zone K-11 (except for the disturbed layer) is the constant increase in importance of herbaceous communities and shrub communities in open habitats, as indicated by the rising percentages of NAP, *Betula nana*, *Juniperus*, and the increasing diversity of herbs, notably in subzones K-11c and K-11d.

In subzone K-11a Cyperaceae-Poaceae, the pollen proportions of trees and shrubs, ranging from 65.2 to 69.4% indicate the fairly important role still played by forest communities in the Konieczki neighbourhood, although they no longer provided dense cover. The high pollen proportion of *Pinus sylvestris* type and the rising values of *Betula* undiff. prove the dominant significance of pine and pine-birch communities. Patches of alder communities with *Osmunda cinnamomea* and *O. regalis* or *O. claytoniana* were still present. It may also well be that *Pterocarya* and *Buxus* persisted in isolated habitats.

The high proportion of NAP, reaching 35%, and the great variety of herbaceous taxa point to the spread of open communities of various type, as in the declining part of zone K-10 *Pinus*. *Betula nana* occurred in damp habitats, its presence in the vicinity of the lake being confirmed by nutlets.

In subzone K-11b *Betula*, which comprises a considerable part of the disturbed layer, the pollen value of *Betula* undiff. increases to 28.3%. It seems likely, however, that this increase was not induced by redeposition processes but resulted from natural changes accompanying the growing importance of birch in forest communities. On the other hand, it may be supposed that the fairly high pollen values of *Alnus glutinosa* type, not only in this subzone but also later in subzones K-11c and K-11d, are to a great extent due to redeposition. This is also true of *Buxus* and *Pterocarya* pollen.

In subzone K-11c Cyperaceae-*Betula nana*-*Juniperus*, pine and pine-birch communities were still of great importance. Fragments of needles of *Pinus cembra* and the 1.6 per cent proportion of *Larix* pollen show that these trees may have occurred in the forest stands. Despite very low pollen values of *Quercus*, a piece of its wood found in the deposits of subzone K-11c indicates that oak may have constituted a singular admixture in the pine forest in fresh or moist habitats. The understorey was still fairly heterogeneous with *Frangula alnus*, *Sambucus racemosa*, *S. nigra* and *Juniperus* growing in it. *Stellaria nemorum*, *Arctostaphylos*, *Calluna vulgaris*, *Pteridium aquilinum, Lycopodium annotinum* and *Botrychium* were present in the herb layer of the forest.

The small but continuous rise in the NAP value throughout subzone K-11c provides evidence of the progressive spread of open habitats, occupied by herbaceous plants. Shrub communities, whose photophilous nature is emphasized by the occurrence of pollen of *Ephedra* distachya type, *E. fragilis* type, *E.* cf. *strobilacea* and *Hippophaë rhamnoides*, also gained in significance. They may have been accompanied by *Juniperus* and *Rosa* as well. In moist habitats *Betula nana* occurred more abundantly than previously. Its presence in the vicinity of the lake is confirmed by nutlets, fruit scales and pollen. In shrub communities with dwarf birch there grew also shrub willows (*Salix glauca* type). In spite of low pollen values, their presence in the neighbourhood of the lake is shown by the occurrence of *Salix* wood, which most probably is that of a shrub willow. These communities are also the source of spores of *Selaginella selaginoides*.

In the lake littoral zone, in periodically exposed habitats, some nitrophilous communities containing *Rorippa palustris*, *Ranunculus sceleratus* and *Rumex maritimus* may have been growing. This is suggested by the presence of their macrofossils. Species represented by pollen of *Polygonum persicaria* type probably occurred as well. The presence of pollen of *Polygonum aviculare* type, *Plantago major*, cf. *Chamaenerion*, *Potentilla* and *Geum* may also point at the occurrence of nitrophilous communities. These communities existed presumably until the decline of subzone K-11c with *Ranunculus sceleratus* being particularly well represented.

Mint grew in wet habitats linked directly with the littoral zone or in swamp communities (fruits of *Mentha*), while *Potentilla supina* occurred in moist sandy habitats as is indicated by its single fruits.

The proportion of Poaceae undiff. pollen, oscillating within limits of 10.1–16.7% in subzone K-11c and the presence of pollen of *Artemisia*, *Plantago media*, *Helianthemum nummularium* type, *H. canum* or *H. alpestre, Rumex acetosella* type, *Pimpinella, Anemone* type and Chenopodiaceae may reflect the then developing grassland communities, probably mainly on sandy soils.

The sporadic presence of pollen of *Armeria maritima* and *Plantago maritima* s.l. may indicate the existence of halophilous communities in the lake surroundings. Presumably, however, they were not widespread.

A further increase in the herbaceous plant pollen value up to 47%, visible in subzone K-11d Poaceae-*Artemisia*, and the great diversity of taxa, provide the strongest possible evidence of the continuously progressing expansion of various herb communities. A distinct increase in the pollen values of Poaceae undiff. and *Artemisia* suggests the growing importance of grass communities, perhaps steppe-like in nature. Pollen of *Helianthemum nummularium* type, *H. canum*/*H. alpestre* and *Gypsophila fastigiata* type is probably associated with these communities. The occurrence of *Knautia* pollen may be referred to damp mineral soils and *Polemonium* to wet meadows.

Another feature of subzone K-11d, distinguishing it from K-11c, is the more widespread occurrence of *Betula nana*.

Although the forest communities were subject to continual constraint, it seems that in subzone K-11d stands of pine woodland with a small admixture of birch were still present in the Konieczki region landscape.

AQUATIC AND SWAMP VEGETATION

The changes which took place in the communities of aquatic and swamp plants have been reconstructed with reference to the division into local plant macrofossil assemblage zones in association with the results of pollen analyses. The development of aquatic and swamp vegetation is here presented separately from that of the terrestrial vegetation, because the distinguished pollen assemblage zones and plant macrofossil assemblage zones, in general, show little overlap.

Mazovian Interglacial

KM-1 L MAZ (Pollen assemblage zones: K-1 to the older part of K-9).

The very few plant macrofossils which were found in the lower and middle parts of the profile, which embrace the pollen assemblage zones K-1 to the older part of K-9, are insufficient to form a basis for a more detailed reconstruction of the changes and nature of the vegetation of the lake and its littoral zone. The interpretation of the interglacial local communities from these parts of the profile is therefore almost exclusively based on pollen-spore findings.

The initially low organic matter content (about 15%) in the deposits of pollen zones K-l – K-3 indicates a rather poor growth of vegetation within the lake itself. This would seem to be confirmed by the presence of single pollen grains of aquatic taxa and their small variety. Such a situation may have resulted from the great depth of the lake in the initial stage of its development.

Pollen of *Potamogeton* sect. Eupotamogeton provides evidence of the presence of pondweeds in the waters of the lake. *Myriophyllum spicatum* occurred in fairly shallow places and *Pediastrum* was present in small numbers. The singly appearing pollen grains of *Typha latifolia* and *Sparganium* type show that these plants grew, although not very abundantly, in the littoral belt of the lake, where *Scirpus atroviroides* (fruits) also occurred.

The occurrence of *Potamogeton perfoliatus* in the deposits of zone K-3 and *P.* cf. *gramineus* in zone K-4 (single endocarps) may also suggest low nutrient levels in the lake (Zarzycki 1984). Despite a slight increase in the organic matter content in the deposits in pollen zones K-4 and K-5, the aquatic vegetation was probably still pretty poor.

The oligotrophic nature of the lake is further indicated by the presence of *Isoëtes* cf. *lacustris*, which probably occurred in the littoral, towards the end of zone K-4 and still at the beginning of zone K-5, where the proportion of its microspores was about 1.9%. They disappear completely in the middle part of zone K-5. It may therefore be supposed that a process of transformation began in the water body at that time, leading to a gradual increase in its fertility.

The conditions prevailing in the lake probably did not undergo radical improvement before the younger part of zone K-5, as is intimated by the appearance of the pollen of many aquatic plants characterized by their high nutritional requirements. These were *Nymphaea candida, N. alba, Myriophyllum verticillatum, Polygonum amphibium* and *Ceratophyllum*. Pollen of *Trapa* and single microsporangia of *Salvinia natans* also point to the eutrophic nature of the water body.

The results of a pollen analysis for zones K-6 – K-9 indicate that no significant changes affected the aquatic vegetation throughout that time. The variety of swamp plants increased only slightly with *Butomus umbellatus* and *Lysimachia thyrsiflora* being the only significant additions to the taxa present earlier.

KM-2 L MAZ (Younger part of zone K-9 *Abies-Carpinus-Alnus*)

A change takes place in the lithological profile in the middle part of zone KM-2. Gyttja gradually passes into peat.

Presumably the decrease in depth produced favourable conditions for the development of communities of rooted plants in which *Potamogeton natans* was probably dominant, judging by its numerous endocarps. Pollen of *Nymphaea alba, Nuphar lutea, Myriophyllum spicatum*, pollen and macrofossils of *Trapa* and fruits of *Ceratophyllum demersum* suggest that these plants also occurred in the communities.

The simultaneous appearance of a large number of macrosporangia and macrospores of *Salvinia natans* is evidence of its profuse development in the lake waters.

The rise in the number and diversity of macrofossils of reed and sedge swamp plants in the youngest part of KM-2 proves that the reedswamp zone developed more luxuriantly than before. *Typha*, which had been growing in the littoral area up to then, managed to expand to new sites as a result of the shallowing of the lake. The appearance of fruits of *Carex elata*, *C. gracilis* and *C. rostrata* indicates the beginning of changes leading to the encroachment into the lake of peat-forming communities.

Aracites interglacialis was probably growing in communities associated with the lake littoral (Łańcucka-Środoniowa 1966), as its seeds have been found in this zone.

Mazovian Interglacial/Early Glacial

M-3 L MAZ (Pollen assemblage zones: K-10 and the oldest part of K-11)

The slow processes of the shallowing and colonization of the lake that had started as early as the middle part of zone KM-2 continued in zone KM-3. These processes found their expression in the formation of peat.

The fairly numerous nutlets of *Carex gracilis, C. elata* and *C. rostrata* point to the development of sedge communities. The extant macrofossils and pollen show that in these communities abounded a huge number of accompanying species, among which may have been *Comarum palustre, Menyanthes trifoliata, Lysimachia vulgaris* (*L. vulgaris* type) and *Caltha palustris* (*Caltha* type). The abundant occurrence of fruits of *Eleocharis praemaximoviczii* is evidence that this extinct plant grew in shore communities at that time. Perhaps, like *E. ovata, E. praemaximoviczii*, too, occurred in habitats inundated for a greater part of the year or periodically exposed, and maybe also in wet meadows. *Alisma plantago-aquatica, Sagittaria sagittifolia, Schoenoplectus lacustris, Lysimachia thyrsiflora* etc. may have occurred in stands of these communities.

The water body, which not long before had still been characterized by a high degree of fertility, was gradually becoming poorer in nutrients. The appearance of numerous fruits of *Najas flexilis* points to the vigorous development of communities containing it. The presence of remains of *Zannichellia palustris, Potamogeton perfoliatus, P. pusillus, P. praelongus, P. obtusifolius, Ceratophyllum demersum, Callitriche autumnalis* and pollen of *Myriophyllum spicatum* and *M. verticillatum* indicates that these plants may also have formed part of such communities.

Chara fragilis, whose oospores appeared in this zone, could have occurred as an accompanying species because of its broad ecological tolerance (Dąmbska 1964), but presumably formed small stands in communities of its own. It would probably have been accompanied by *Stratiotes aloides, Potamogeton pusillus, P. perfoliatus, Ceratophyllum demersum* and *Myriophyllum spicatum.*

Early Glacial

KM-4 L MAZ (Subzone K-11c Cyperaceae-*Betula nana-Juniperus*, excluding the top part)

In the oldest part of KM-4 the moss-sedge peat-bog continued to develop, followed by the sedimentation of organic silts.

The composition of macrofossils shows that the plant communities growing in the lake were rather species poor. The abundant occurrence of fruits of *Callitriche autumnalis* provides evidence of the deterioration in trophic conditions in the lake. The fall in the number of fruits of *Najas flexilis* shows that the communities containing it, widespread in the previous zone, had almost entirely lost their significance. The stonewort meadows, consisting chiefly of *Chara fragilis*, presumably survived with their composition unchanged.

Fruits of *Dulichium spathaceum*, found in the older part of the zone, show that this thermophilous plant was still growing in the shore area of the lake. It may be supposed that, despite unfavourable conditions, it had managed to persist from the climatic optimum period, although there is no evidence of its occurring in that section of the interglacial.

At first, only modest changes took place in the reed and sedge swamp communities. It can be inferred from the comparatively numerous nutlets of *Carex gracilis* and *C. rostrata* present, that communities in which these sedges were the main constituents dominated. However, communities containing *Carex pseudocyperus* and *C. vesicaria* (nutlet of *C.* cf. *vesicaria)* were present as well. By the shore some low sedge swamp communities with *Eleocharis palustris* or *E. mamillata* and *E. praemaximoviczii,* suggested by the presence of their fruits, may have grown adjacent to the *Carex gracilis* communities. The silty bottom favoured the development of such low sedge communities, in which *Sagittaria sagittifolia, Schoenoplectus lacustris, Lysimachia thyrsiflo-*

ra and *Hippuris vulgaris* may have been growing in addition to the foregoing species.

Typha was constantly present in the littoral. The subcontinuous pollen curve of *T. latifolia* shows that a considerable proportion of the *Typha* fruits belong to this species. The possibility of pollen grains of *T. angustifolia* occurring among the grains identified as *Sparganium* type is most unlikely. The great majority of pollen grains had thick muri composed of two or even three rows of columellae, which indicates that they represent *Sparganium*.

The low organic matter content (not exceeding 20%) in the deposits in the younger part of the zone and the few macrofossils of aquatics suggest the increasingly poor development of vegetation in the water body.

The vanishing of oospores of *Chara fragilis* and the appearance of rather large numbers of oospores of *Nitella opaca* point to changes leading to the further impoverishment of the water body. The species composition of the communities too was very poor. *Myriophyllum spicatum* and *Batrachium* supposedly occurred in addition to stoneworts.

KM-5 L MAZ (Decline of subzone K-11c Cyperaceae-*Betula nana-Juniperus*)

The low organic matter content (about 15%) in the deposits demonstrates the deteriorating climatic conditions responsible for changes in the composition and further impoverishment of plant communities in the lake.

Evidence of the decreasing fertility of the lake is the mass appearance of fruits of *Callitriche autumnalis*, which perhaps occupied a large part of its surface. The underwater communities chiefly of *Nitella opaca*, floristically very poor, still survived. *Sagittaria sagittifolia* and *Typha* grew sporadically in the littoral.

KM-6 L MAZ (Subzone K-11d Poaeae-*Artemisia*)

The very low organic matter content (2.0–5.0%) in the deposits reflects the very low developmental state of vegetation in the water body. The almost complete lack of macrofossils shows that aquatic plants were only sporadically present. The underwater stonewort communities had almost completely disappeared. The oospores of *Nitella opaca* turn up in very small numbers but are confined to the older part of the zone. *Batrachium* sporadically occurs.

CLIMATE

Mazovian Interglacial

Sedimentation of the organic deposits drilled at Konieczki started as early as the interglacial period. Dense forest, which had already become a dominant feature of the landscape of the lake surroundings by that time, shows that favourable climatic conditions, probably with fairly high temperatures, prevailed. At first, the forest was merely birch woodland with only a small admixture of pine, but its poor species composition was perhaps due more to poorly developed soils than to an unfavourable climate, for the occurrence of pollen grains of *Typha latifolia* in the bottom part of the profile indicates that the mean temperature for the warmest month was above 14–15°C (Mamakowa 1989 after Iversen 1944) and so 2–3° higher than that implied by the presence of *Betula pubescens* and *B. pendula* (Mamakowa 1989). The early appearance of alder and spruce in forest communities points to good thermal conditions.

Towards the end of pollen period M I many trees and shrubs with higher thermal requirements, such as *Quercus, Fraxinus, Hedera helix, Frangula alnus* and *Viburnum* grew in the forest communities. The appearance of *Hedera helix* in the declining part of pollen period M I suggests that the climate was becoming oceanic, and characterized by moderately high summer temperatures with the mean temperature of the coldest month not falling below -1.5°C (Mamakowa 1989 after Iversen 1944).

A further improvement in climatic conditions in the older part of pollen zone M II is indicated by the intense development of alder communities with *Fraxinus,* and an increase in the role of *Quercus* and *Tilia cordata* (*T. cordata* type) in the forest communities. The appearance of *Ilex aquifolium* type pollen during the formation of zone K-4 *Alnus-Picea-Fraxinus,* provides evidence of a mild climate with oceanic characteristics and the mean temperature of the coldest month not below -0.5°C (Mamakowa 1989 after Iversen 1944).

Such a mild climate, oceanic in nature, is also suggested by the exceptionally abundant occurrence of *Taxus* (West 1962) in the forest communities of the Konieczki area. The presence of pollen of *Ligustrum* and *Cornus* *sanguinea* may suggest the development of highly thermophilous thickets with privet and dogwood in the course of zone K-5 *Taxus-Alnus-Picea*; nowadays these shrubs exhibit an oceanic-submediterranean type of distribution (Matuszkiewicz 1981).

The presence of *Buxus,* most probably *B. sempervirens*, which represents the present-day submediterranean element (Godwin 1975 after Walter & Straka 1970), also indicates a mild climate. *Buxus* pollen appeared early, even in zone K-5 *Taxus-Alnus-Picea*, but reached its highest values with a maximum of 1.9% in subzone K-9a *Buxus-Vitis*, during which its occurrence in the forest communities was certainly substantial in the Woźniki-Wieluń Upland.

A further corroboration of favourable climatic conditions is the presence of *Vitis* (*V. sylvestris*), whose pollen turned up in subzone K-5b *Carpinus-Quercus* and occurred comparatively abundantly, together with *Buxus,* throughout zone K-8 *Abies-Taxus-Corylus*. Today *V. sylvestris* grows mainly in southern Europe and its isolated stands along the valleys of large rivers reach the lowland parts of Austria, southern Germany and north-eastern Switzerland (Ralska-Jasiewiczowa 1980, after Hegi 1965).

On the basis of the presence of *Vitis,* Godwin (1975) writes, referring to Turner (1970), that "even in the late period of the Hoxnian Interglacial (=Mazovian Interglacial) the climate of summer was at least as warm as and probably warmer and more humid than the present-day climate of north-eastern Europe".

The presence of *Salvinia natans* and *Trapa* in the pollen zones of the younger part of pollen period M II and in period M III provides evidence of warm and well sunlit lake waters in summer.

An analysis of the pollen diagram indicates, however, that the climatic conditions were not uniformly favourable throughout the interglacial optimum, for there was a short but cool oscillation at the beginning of pollen period M III (subzone 6a). This is suggested by the high pollen values of *Betula* undiff. and *Pinus sylvestris* type with simultaneous low values of *Quercus*, *Carpinus*, *Corylus* and *Taxus*.

The effect of the worsening climatic conditions towards the end of period M III was seen in a gradual increase in the significance of pine in the forest communities and a drop in the proportion of thermophilous broad-leaved trees and *Taxus*. A further cooling during the course of zone K-10 *Pinus* produced a vigorous expansion of pine and the complete withdrawal of *Quercus* and *Carpinus,* as well as a rise in importance of open communities. This period is represented at the Konieczki site by a very thin layer of deposits, which may be connected with the nature of the sedimentation processes or possibly with an incomplete section of the lithological profile at this place.

The climate at the decline of the interglacial, however, cannot have been too unfavourable, because *Pterocarya*, represented by pollen levels of up to 2.5%, appeared at that time. In all probability, it was *P. fraxinifolia*, the only species growing in Europe today, limited to the Caucasus and the region of the Caspian Sea (cf. Godwin 1975). The presence of *P. fraxinifolia* indicates a warm and, at the same time, humid climate (cf. Szafer 1954). And such a climate may have prevailed to the end of the Mazovian Interglacial.

Early Glacial

The high pollen values of herbaceous plants, and the great diversity of their taxa, provide evidence of the increased importance of open communities in the lake region as a consequence of the further cooling of the climate. The occurrence of macrofossils of *Betula nana* from the very beginning of zone K-11 NAP-*Pinus-Betula*, and somewhat later also of its pollen, point to moderately cold climatic conditions prevailing at that time. The sporadically noted spores of *Selaginella selaginoides* also indicate a cool climate.

The decrease noted in the organic matter content of the deposits all through subzone K-11c, is further evidence of climatic cooling. In subzone K-11d the organic matter content comes down to about 2%, which points both to sparse vegetation within the lake itself and to the small quantities of allochthonous organic matter transported into it.

The low pollen values of trees suggest that the forests survived only in the form of isolated stands. The foregoing data lead to the conclusion that the climate prevailing throughout zone K-11, representing the first cooling of the Early Glacial, was boreal-subarctic and at the end of the zone perhaps even subarctic.

A COMPARISON OF THE POLLEN SUCCESSION FROM KONIECZKI WITH THE SUCCESSIONS FROM OTHER SITES OF ORGANOGENIC DEPOSITS OF THE MAZOVIAN INTERGLACIAL

During the last ten years the profiles from the Krępiec (Janczyk-Kopikowa 1981, 1991) and Biała Podlaska sites (Krupiński et al. 1986, Krupiński 1988) have been regarded as stratotype profiles of the Mazovian Interglacial in Poland.

The pollen succession from Konieczki has all the characteristics that, according to Szafer (1953) and Janczyk-Kopikowa (1991), are typical of the Mazovian Interglacial succession.

The differences between the diagram from Konieczki and those from the recognized stratotype sites are caused by the influence of local conditions on the forest communities. They are, above all, expressed by the different percentage pollen values of individual tree genera. This is particularly true of the very high proportion of *Taxus* at Konieczki (62.1%), because such high pollen values of yew have not hitherto been noted from any interglacial in Poland. Higher values of its pollen, reaching 80% (with the remaining 20% consisting of *Corylus*), are given from the site of the Eemian Interglacial at Zeifen (Jung et al. 1972). The relatively high pollen values of *Taxus* persist at Konieczki until the decline of period M III, whereas at Krępiec they remain only to the end of period M II.

The pollen values of spruce noted from Konieczki are much lower than those in the succession from Krępiec and the maximum frequency of *Carpinus* does not fall between the two maxima of *Abies*. The succession from Konieczki differs from that of the Krępiec site in its much lower pollen values of *Carpinus*.

From among the sites of organic deposits so far studied, situated in the Woźniki-Wieluń Upland and its close vicinity (Fig. 1) and referred to the Mazovian Interglacial, the best-developed succession is represented by the profiles from Radziechowice and Kolonia Dubidze (Fig. 5). Borówko-Dłużakowa (1981) put these two profiles together to form a synthetic one and divided the pollen succession into five floristic phases. They correspond to the four pollen periods distinguished by Szafer (1953) and Janczyk-Kopikowa (1981).

The Konieczki site is situated about 30 km south-west of Radziechowice and Kolonia Dubidze. In spite of this small distance some substantial differences can be seen in the pollen diagrams. For the most part, they are caused by the varying proportions of *Taxus* pollen: at Radziechowice its maximum values are scarcely 17.5%, whereas at Konieczki 62.1%. Yew retreated from the Radziechowice area before the appearance of fir, and its habitats were taken over by pine. In the Konieczki region yew was an essential constituent of forest communities nearly all through period M III. Its maximum pollen values still came up to 21.0% during that time. The very high frequency of *Taxus* and its nearly constant presence till the decline of period M III significantly influenced the composition of the forest communities of the Konieczki region. The situation was presumably determined by microclimatic conditions, particularly favourable in the surroundings of the lake. This region is somewhat higher and receives more rainfall than the Radziechowice region. In the village of Dobryszyce, near Radziechowice, the annual rainfall averages 557 mm, at Wręczyce near Konieczki 665 mm (Dubaniewicz 1974).

Ash is another tree responsible for the differences occurring in the pollen succession between the two sites. The high pollen value of *Fraxinus* in the diagram from Konieczki shows its great importance in the alder communities and, moreover, the broad extent of moist and fertile ash-alder communities. The sporadic occurrence of *Fraxinus* pollen in the Radziechowice diagram points, in all probability, to the very reduced proportion of this tree in the riverine communities. It may be supposed therefore, that in the Radziechowice area, alderwoods were dominant in wet habitats at that time what is demonstrated by very high proportion of *Alnus* pollen.

The abundant occurrence of yew communities, and later the hornbeam communities were the main factors preventing the development of pine communities in the Konieczki area. If zone K-6 *Carpinus-Pinus-Betula* is discounted the role of pine in the Konieczki neighbourhood did not increase until the decline of period M III, when the trees with greater climatic requirements began to retreat. This was not the case in the Radziechowice region. The high proportion of *Pinus* pollen noted there in the climatic optimum, especially in period M II, and the low pollen

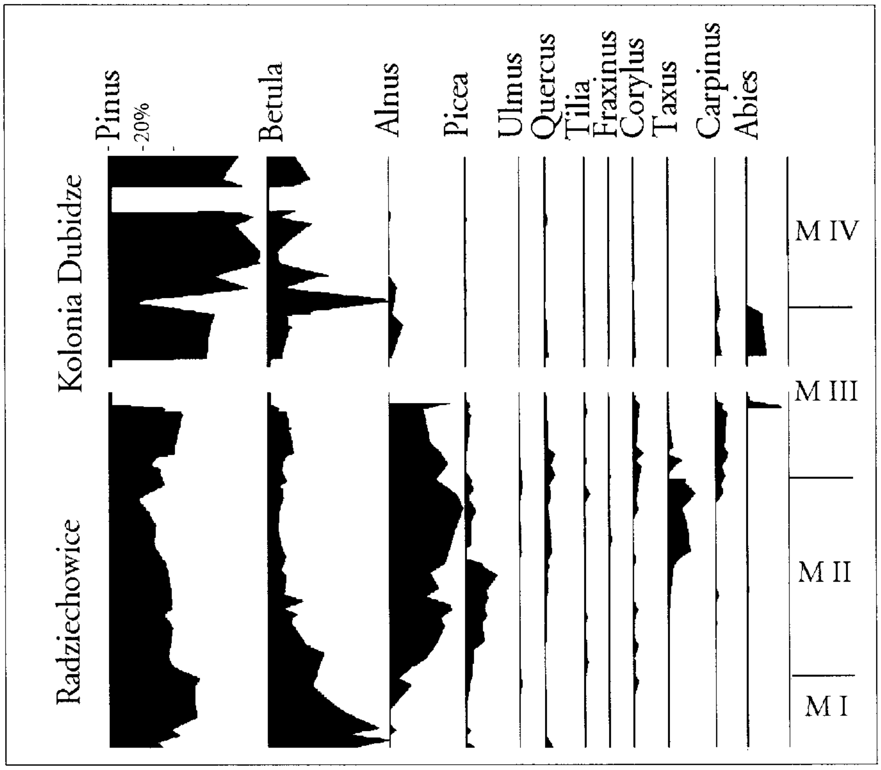

Fig. 5. Pollen diagram from Radziechowice and Kolonia Dubidze (Borówko-Dłużakowa 1981; simplified, modified)

values of *Carpinus* (max. 8.5%) and *Quercus* (about 8%) provide evidence of the much higher contributions of pine forest and the limited spread of the hornbeam communities.

The Kuźnia Borecka site (Kuszell 1986, 1998) lies about 15 km SSW of Konieczki. It is represented by two profiles, but only profile S-541, covering pollen periods M I, M II and M III, contains a section of the interglacial succession that is suitable for comparison with that from Konieczki (Fig. 6a).

In comparison with the diagram from Konieczki, that from Kuźnia Borecka shows higher values of *Picea* (max. 30%), *Alnus* (up to 50%) and *Pinus*, especially in period M II, while *Taxus* pollen occurs only sporadically.

The small distance of Kuźnia Borecka from Konieczki would suggest the occurrence of far higher values of *Taxus*. And so the question arises as to whether profile S-541 from Kuźnia Borecka lacks the deposits whose formation would have fallen in the period of the maximum development of yew. If such a situation did not occur, then, based on the tiny per mil values of *Taxus* pollen, one must assume that its role in the forest communities of the Kuźnia Borecka area was insignificant. Single pollen grains of *Fraxinus* in the diagram from Kuźnia Borecka lead to a similar conclusion concerning the role of ash in the forests of that region.

Studies at the remaining sites in the Woźniki-Wieluń Upland, that is, Herby and Malice, have been somewhat superficial, unsupported by pollen diagrams. The results of pollen analyses of four samples from the Borki profile, in Borówko-Dłużakowa's (1981) opinion, do not exclude their Mazovian Interglacial origin; nevertheless, they could belong to another stratigraphical unit.

Summing up the findings from the Woźniki-Wieluń Upland, one should emphasize the fact that so far no remains of water fern *Azolla filiculoides* have been found in this terrain.

There are several other sites of the Mazovian Interglacial not far from Konieczki but outside the area of the Woźniki-Wieluń Upland. The most important of them are Barkowice Mokre (Sobolewska 1952), Olszewice (Sobolewska 1956b), Sewerynów (Jurkiewiczowa & Mamakowa 1960), Gościęcin (Środoń 1957), Stanowice (Sobolewska 1977) and Kuców (Krzyszkowski 1989).

In studies from these sites carried out in the 1950s *Taxus* pollen was not recorded, except from Gościęcin. If yew is omitted, the pol-

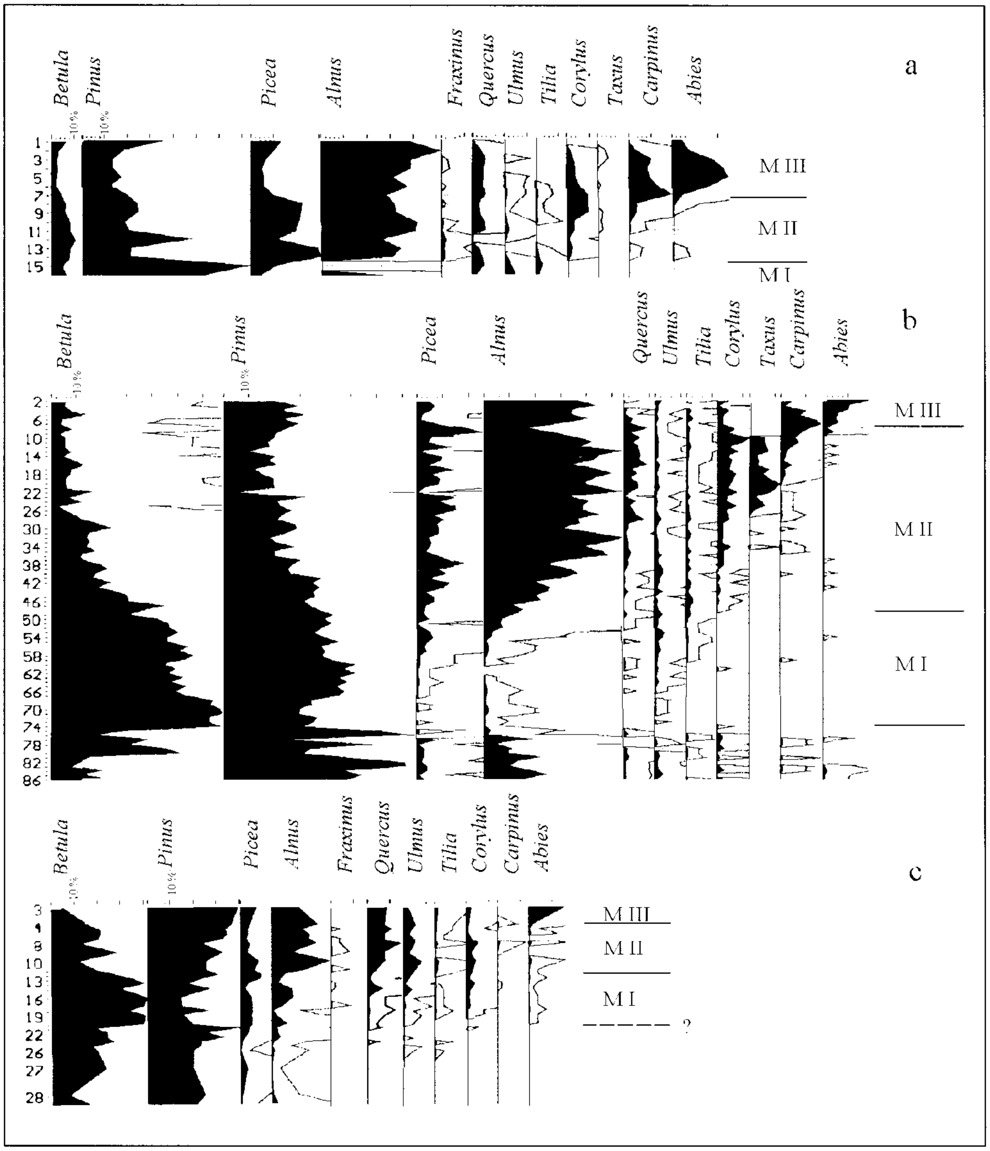

Fig. 6. Pollen diagrams from: a. Kuźnia Borecka (Kuszell 1986, 1998; simplified, modified), b. Gościęcin (Środoń 1957; simplified, modified), c. Kuców (Krzyszkowski 1989; simplified, modified)

len succession from the Konieczki site will very much resemble those from Olszewice and Barkowice Mokre. The pollen values of individual tree genera approach one another, with only the proportion of *Abies* pollen somewhat higher at Barkowice Mokre, where it reaches 36%. At Sewerynów near Przedbórz the proportion of fir pollen is higher still, with a maximum of 52%.

The Gościęcin site (Środoń 1957) lies about 100 km south-west of Konieczki. Its pollen succession embraces pollen periods M I, M II and, incompletely M III (Fig. 6b). At Gościęcin the proportion of *Taxus* pollen reaches 12% but its presence comes to an end when the *Abies* curve begins and thus earlier than in the succession from Konieczki. Otherwise these two pollen successions very much resemble each other.

At Stanowice, situated not far from Gościęcin, the organic deposits represent two pollen periods: M III and M IV (Sobolewska 1977). Pollen of *Taxus* appears there only sporadically. The lack of the older part of the interglacial does not allow direct comparison of the successions from Stanowice and Konieczki with respect to the behaviour of yew, but the progress of the succession in pollen period M III is alike at the two sites.

The pollen diagram from Konieczki, however, differs very distinctly from that from Kuców (Bełchatów region), studied by Janczyk-

Kopikowa (Krzyszkowski 1989). There the organic deposits represent pollen periods M I, M II and a small fragment of M III (Fig. 6c). This notwithstanding, *Taxus* pollen has not been found there, even sporadically. The *Carpinus* curve is not continuous and the values of its pollen are very low. However, this could be due to the incompleteness of the profile, because above sample No 4 the deposit changes from peat into organic silts.

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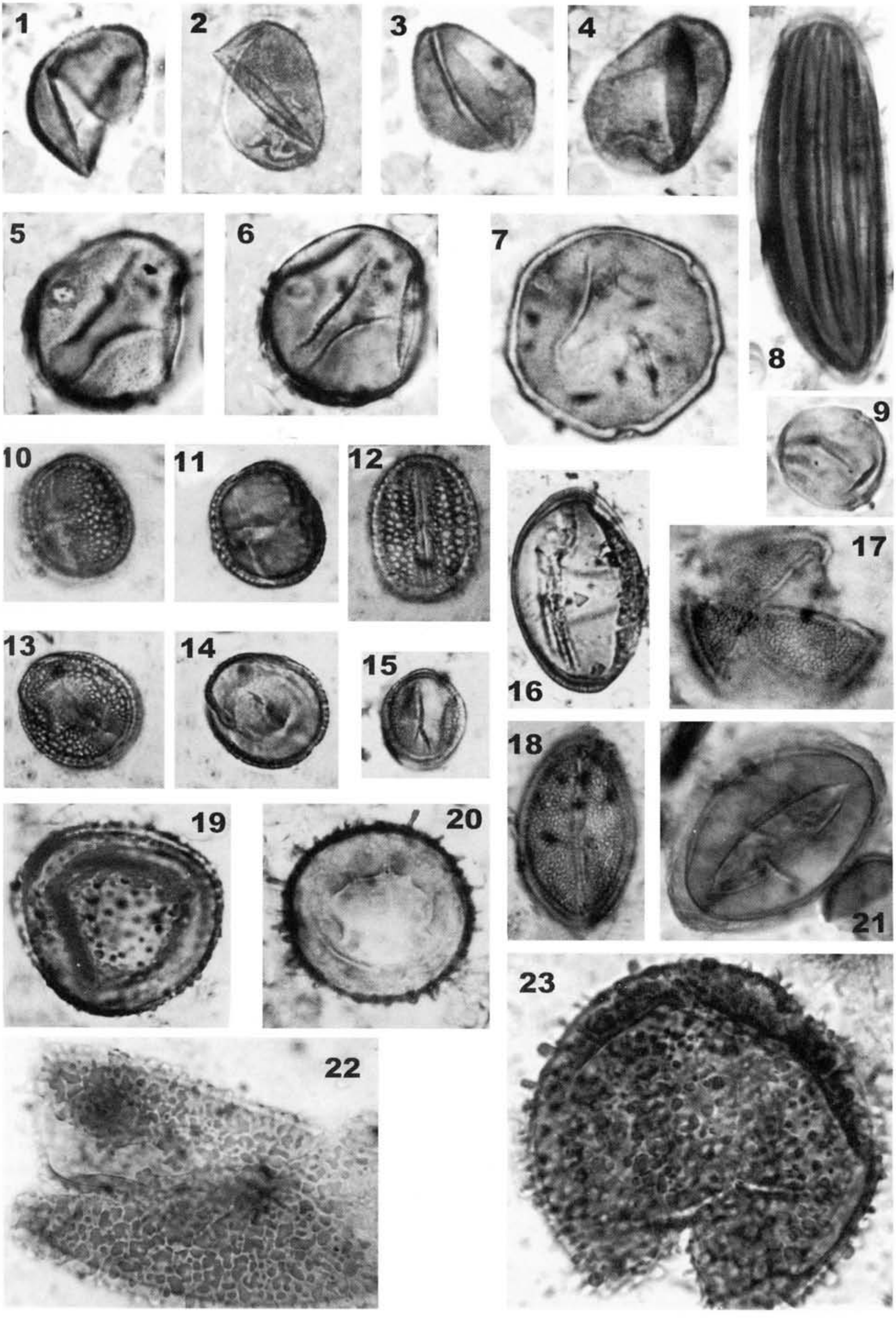
STRESZCZENIE

Celem pracy jest przedstawienie rozwoju roślinności na Wyżynie Woźnicko-Wieluńskiej w interglacjale mazowieckim i w początkowym okresie następującego po nim zlodowacenia na podstawie wyników badań paleobotanicznych (analiza pyłkowa i analiza szczątków makroskopowych). Wyróżniono jedenaście lokalnych poziomów zespołów pyłkowych (L PAZ), z których dziesięć reprezentuje interglacjał mazowiecki oraz sześć lokalnych poziomów zespołów szczątków makroskopowych roślin (L MAZ). Lista florystyczna zawiera 251 taksonów różnej rangi, w tym 106 oznaczonych do poziomu gatunku. Charakterystyczną cechą sukcesji pyłkowej jest bardzo wysoki udział pyłku *Taxus*, z maksimum przekraczającym 60%. Wśród szczątków makroskopowych na szczególną uwagę zasługuje *Aracites interglacialis*, gatunek wymarły, charakterystyczny dla flor mazowieckich, znany z kilku stanowisk w Polsce. Sukcesję z Konieczek porównano z sukcesjami z trzech stanowisk z Wyżyny Woźnicko-Wieluńskiej oraz z kilkoma innymi sukcesjami interglacjału mazowieckiego z terenu Polski. Istniejące różnice, spowodowane głównie przez różny udział pyłku *Taxus, Fraxinus* i *Pinus* są związane z warunkami lokalnymi.

Plate 1

1–4. *Taxus*, × 1000
5–6. *Celtis*, × 1000
7. *Pterocarya*, × 1000
8. *Ephedra* cf. *strobilacea*, × 1000
9. *Betula nana*, × 1000
10–11. *Lysimachia vulgaris* type, × 1000
12. *Lysimachia nummularia*, × 1000
13–14. *Lysimachia thyrsiflora*, × 1000
15. *Hottonia palustris*, × 1000
16. *Aconitum*, × 1000
17–18. *Stachys sylvatica* type, × 1000
19. *Nymphaea candida*, × 1000
20. *Nymphaea alba*, × 1000
21. *Isoëtes* cf. *lacustris*, × 1000
22. *Osmunda regalis*/*O. claytoniana* (fragment), × 1000
23. *Osmunda cinnamomea*, × 1000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