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EEMIAN, EARLY AND LATE VISTULIAN, AND HOLOCENE VEGETATION IN THE REGION OF MACHNACZ PEAT-BOG NEAR BIAŁYSTOK (NE POLAND)

(preliminary results)

Roślinność interglacjału eemskiego, wczesnego i późnego Vistulianu oraz holocenu w okolicach torfowiska Machnacz koło Białegostoku

(doniesienie wstępne)

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ABSTRACT. Two profiles MI and MII taken from Machnacz peat-bog north-east of Białystok were studied by means of pollen analysis. The obtained results enabled the reconstruction of local changes in vegetation during the Eemian Interglacial and Early Vistulian (the pollen diagram MII), and the Late Glacial and Holocene (the pollen diagram MI).

KEY WORDS: vegetation history, Eemian Interglacial, Early Vistulian, Poland

INTRODUCTION

The Białystok Region belongs to those areas of Poland which have not been described in detail in terms of the history of vegetation in the Late Glacial and Holocene. Until recently Białowieża Primeval Forest has been the only locality analysed palynologically (Dąbrowski 1959).

Recently, palaeobotanical investigations are being carried out in the area of Machnacz peat-bog in Puszcza Knyszyńska (Fig. 1). The results of peat analysis suggested the Late Glacial origin of this sedimentary basin (Żurek 1989a).

The first boring (MI) performed in the central part of peat-bog (Fig. 2), with the Russian sampler of 5 cm in diameter reached the depth of 4.00 m. For a simplified description of sediments in this profile see Fig. 4.

The following year Dr. S. Żurek and Dr. K. Więckowski made the second boring (MII) located close to the edge of the peat-bog, near the kame hill (Żurek 1990), using Więckowski piston corer. It penetrated through the 0.5 m thick layer of the Holocene peat, 1.5 m layer of sand, and over 2.0 m layer of silt and clay, reaching the older

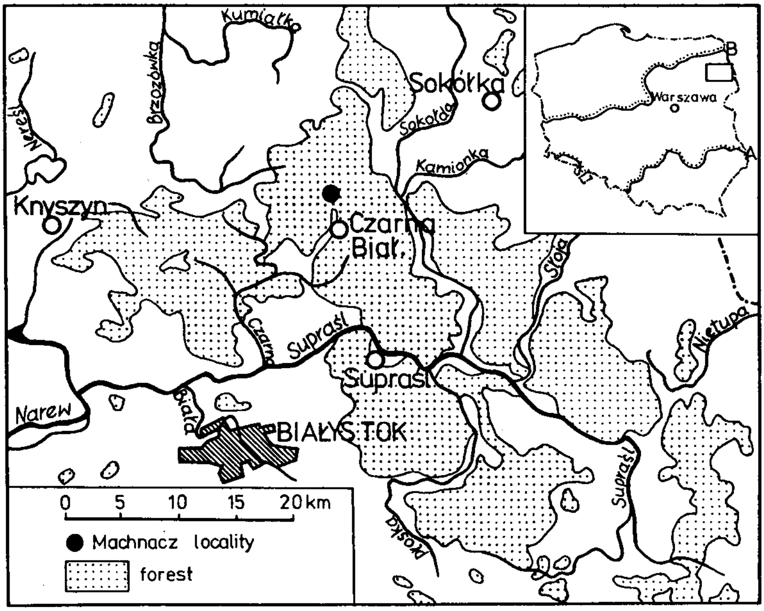

Fig. 1. Location of Machnacz peat-bog. A – maximum extent of Middle Polish Glaciation, B – maximum extent of North Polish (Vistulian) Glaciation (after Galon & Roszkówna 1967)

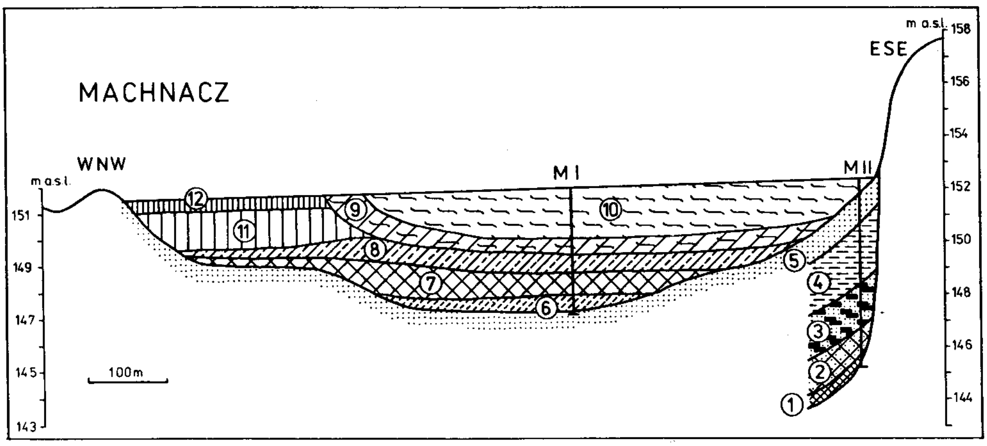

Fig. 2. Geologic section of the Machnacz peat-bog sediments. 1 – calcareous gyttja, 2 – detritus gyttja with sand, 3 – brown peat, 4 – silt and clay, 5 – sand, 6 – brown moss peat, 7 – detritus gyttja, 8 – moss-fen peat, 9 – *Sphagnum-Carex* peat, 10 – *Sphagnum-Eriophorum* peat, 11 – osier peat, 12 – alderwood peat.

biogenic series of peat and gyttja 3.0 m in thickness (Żurek 1989b). The total length of extracted core was ca. 7.0 m. It did not contain, however, the full sequence of sediments. Two gaps (4.50–4.10 m and 3.60–3.30 m) were caused by technical problems.

Four samples of minerogenic and biogenic deposits were dated by the thermoluminescence and radiocarbon methods, respectively. The results of 64 500 years TL from the sandy deposits underlying gyttja, 40 800 BP and 43 500 BP from the upper peat layers and 44 200 years TL from the clay closely overlying the peat (Żurek 1989b), unequivocally indicated their Vistulian age. Since any localities of the interstadials of Vistulian age have not been described uptill now, except for Horoszki (Bitner 1954) situated in relatively long distance south of Białystok, it seemed reasonable to undertake palaeobotanical studies on the Machnacz sequence.

This article presents the preliminary results of pollen analysis covering the whole profile MI, and a part profile MII, including organic sediments (gyttja and peat) and lower section of mineral sediments up to 2.4 m. A pollen analysis of the remaining part of mineral sediments in the profile MII and plant macrofossil analysis in the both profiles will be subjects to further studies by the author.

DEVELOPMENT OF VEGETATION

THE EEMIAN INTERGLACIAL

The results of pollen analysis of the profile MII (Fig. 3) showed that its lower part (to the depth of 4.50 m) represents the descending phase of the Eemian Interglacial and thus appears to contain sediments older than previously suggested.

In the lowermost part of the diagram (7.00–6.80 m) the pollen of *Corylus* predominates. Its contribution to the total pollen sum is about 40%. Percentages of *Alnus, Tilia, Quercus, Ulmus* and *Acer* pollen are also relatively high. The pollen grains of *Hedera, Viscum* and *Ilex aquifolium* occur commonly (not indicated on the simplified diagram in Fig. 3). This part of the diagram (pollen zone MII–1) appears to originate from the late phase of climatic optimum in the Eemian, and represents the dominance of thermophilous deciduous forests with the dominance of hazel.

The rapid increase in *Carpinus* pollen values with the simultaneous decrease in *Corylus* and *Tilia* curves mark the lower boundary of the next pollen zone (MII–2) which is clearly bipartite in the Machnacz diagram.

In the older part of this zone (subzone MII–2a) *Carpinus* pollen predominates, yet *Tilia, Corylus, Ulmus* and *Alnus* pollen is still common. The pollen grains of *Hedera, Viscum* and *Ilex aquifolium* are also encountered. This part of the diagram reflects the expansion of hornbeam forests in conditions of warm and humid oceanic climate.

The younger part of the described pollen zone (subzone MII–2b) is still characterized by the very high percentage of *Carpinus* which attained its interglacial maximum (about 70%) there. There is a conspicuous decrease in the values of *Corylus* and deciduous trees, and a simultaneous relatively rapid increase in those of *Picea* and *Abies*, while the pollen of *Hedera, Viscum* and *Ilex* disappear completely. The above mentioned composition of pollen spectra indicate the persisting dominance of hornbeam forests and, on the other hand, foreruns the ongoing cooling of climate.

The pollen zone MII–3 is characterized by a maximum of *Picea* (30%) and a minor

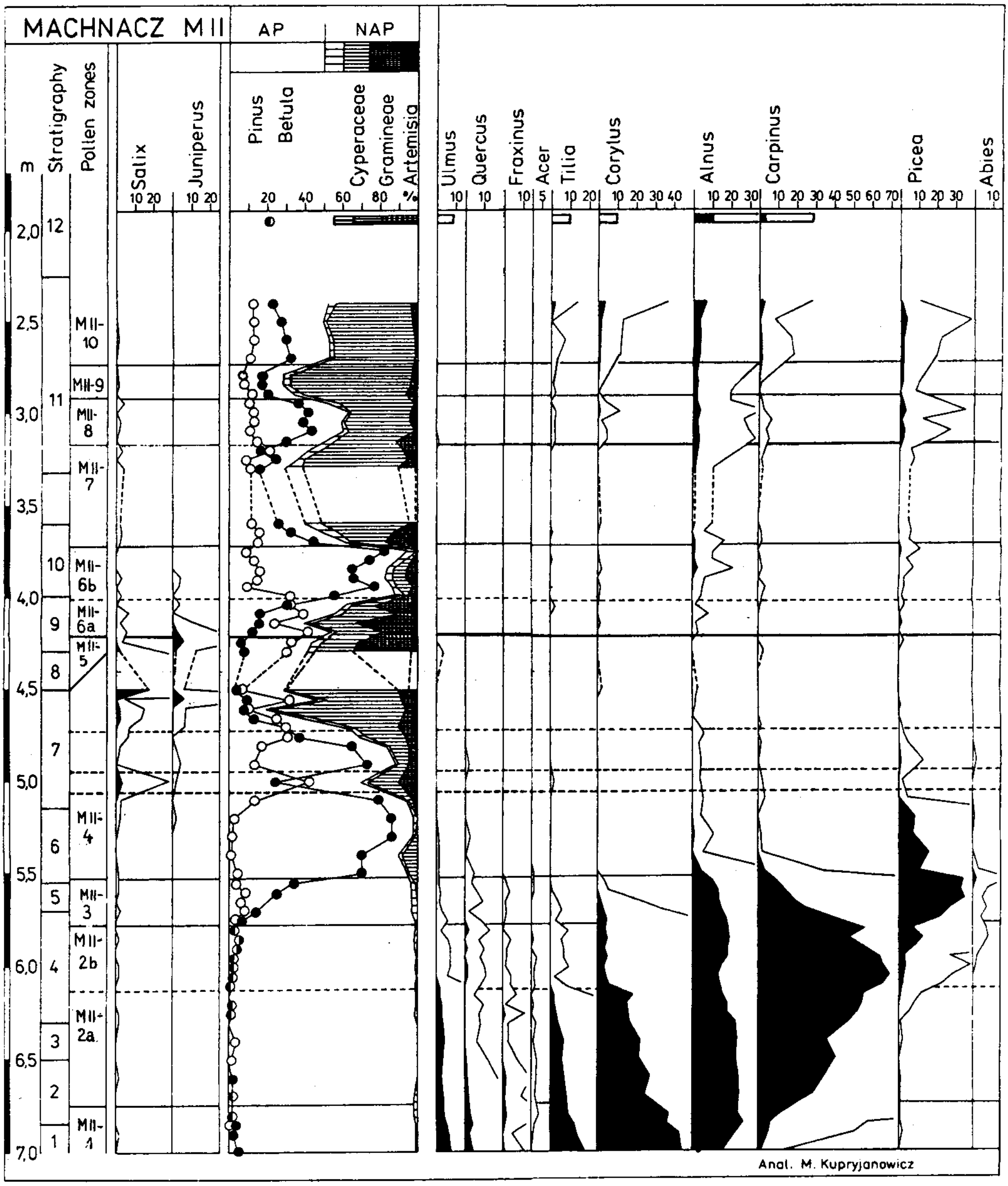

Fig. 3. Simplified pollen diagram MII, selected pollen curves only. Calculation based on the AP + NAP excl. aquatics, *Pteridophyta*, *Sphagnum* and rebedded pollen and spores. Simplified sediment description (Żurek 1989b): 1– grey calcaroeus gyttja, 2 – brown detritus gyttja with sand; fragments of mollusc shells, 3 – light grey sand with gravel; fragments of mollusc shells, 4 – detritus gyttja with sand; fragments of mollusc shells, 5 – brown peat with gyttja and wood fragments, 6 – light brown moss peat with small admixture of sand, 7 – brown peat with frequent *Pinus* and *Betula* wood fragments, 8 – the gap in the profile, 9 – moss fen peat with scattered *Betula* wood, 10 – grey-brown silt with small admixture of sand, 11 – grey-blue silt with sand, 12 – blue clay with small admixture of plant detritus and sand

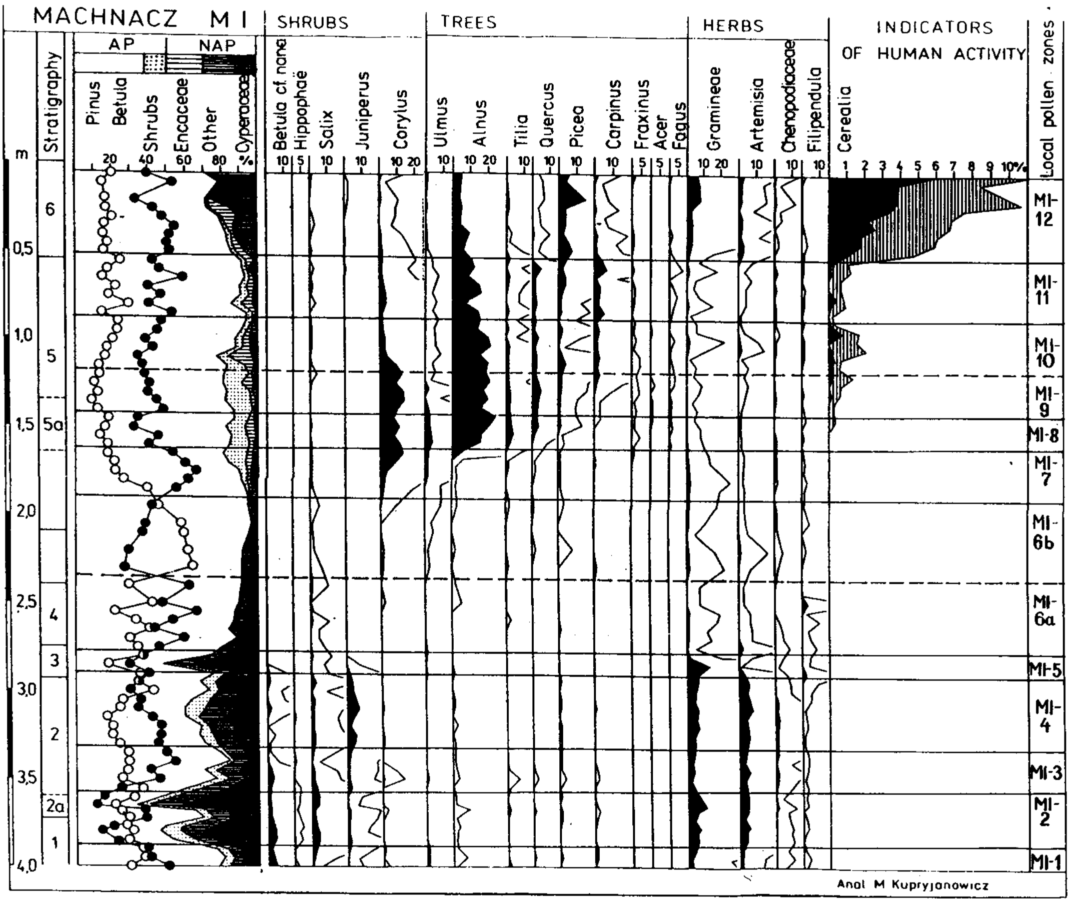

Fig. 4. Simplified pollen diagram MI, selected pollen curves only. Calculation based on the AP + NAP excluding aquatics, *Pteridophyta* and *Sphagnum*. Simplified sediment description: 1 – brown moss peat, 2 – detritus gyttja, 2a – detritus gyttja with sand, 3 – moss-fen peat, 4 – *Sphagnum-Carex* peat, 4a – *Sphagnum* peat, 5 – *Sphagnum-Eriophorum* peat, 5a – *Sphagnum-Eriophorum* peat R–70, 6 – *Sphagnum* peat

rise of *Abies* (ca. 2%) with the increase in *Pinus* pollen values and the decrease in *Carpinus, Alnus* and *Corylus* curves. This period saw the replacement of mixed deciduous forests by spruce forests with a little participation of fir and the gradually decreasing participation o^f hornbeam.

The lower boundary of the MII–4 pollen zone is delimited by the rapid increase in the *Pinus* pollen curve (to 80%). This zone represents the final period of the Eemian Interglacial. The investigation area was, at that time, covered with pine forests with a little contribution of spruce, and later of birch. The middle part of the pine zone carries several features which may indicate the temporary change of climatic conditions. It is expressed by a decrease in the percentage of *Pinus,* and *Picea* and an increase in the curves of *Betula* and NAP (mainly *Cyperaceae, Gramineae* and *Artemisia*). This oscillations are confined to the level of 5.00 m only. Shortly above all pollen curves return to their previous values. Similar short-duration oscillations of the abovementioned curves at the decline of *Pinus* zone are also evident in some pollen diagrams of corresponding age from other regions of Poland, eg. from Zgierz-Rudunki site (Jastrzębska-Mamełka 1985).

The location of the boundary between the final phase of Eemian Interglacial and the onset of Vistulian colt-stage presents some difficulty. It is most likely placed between the depth of 4.50 m and 4.30 m. This section of sediment however, was lost during the boring and there is a gap in pollen spectra. Below this section, beginning from the level of 4.65 m, the NAP curve tends to increase, but this is almost solely due to the contribution of *Cyperaceae*, and may in fact, be only of local importance. A detailed analysis of this part of sediments, including plant macrofossil analysis, will be needed to explain this question.

The above described vegetational changes represent the sequence of events typical of the Eemian Interglacial succession. The distinguished pollen zones may easily be correlated with the regional pollen zones (R PAZ) defined by Mamakowa (1989) for the area of Poland, and with local pollen zones determined by other authors in the diagrams from Wysoczyzna Białostocka (Bitner 1956 and 1957; Borówko-Dłużakowa 1973 and 1974).

THE EARLY VISTULIAN

The description of vegetation in early Vistulian was based on the upper part of the pollen diagram MII above the depth of 4.30 m (Fig. 3). The lowermost section of this part of pollen diagram (pollen zone MII–5) represents the open vegetation typical for a cool stadial. In the pollen spectra mainly *Gramineae* (30%), *Cyperaceae* (20%), *Artemisia* (5%), *Juniperus* and *Salix* are dominant. The investigation area was at that time covered by a shrub tundra with quite a large proportion of juniper, willows and birches (probably including *Betula nana*).

The section between 4.20 m and 4.05 m represents the next phase of vegetation development during the Early Vistulian (pollen subzone MII–6a). There are two peaks of *Betula* pollen and a consistent rise of *Pinus* curve. The NAP sum is high (about 50%) with a maximum after the first peak of *Betula* pollen.

Pollen subzone MII–6b (4.00–3.75 m.) is characterized by a rapid increase of *Pinus* pollen values at the depth of 4.00 m and an abrupt decline in *Betula* and NAP curves. *Sphagnum* spores attain exceptionally high percentage (about 50%) – not indicated on the simplified diagram in Fig. 3. There are continuous curves for *Picea* (about 1%) and *Alnus* (about 1.5%). This pollen subzone represents the period of dominating pine forests with a little contribution of birch, spruce and alder.

The whole zone MII–6 may be correlated with the Brørup interstadial (Behre 1989).

From the depth of 3.70 m begins the record of a new treeless period (pollen zone MII–7). Its lower boundary is marked by the increase in NAP curve to 40% and the decrease in *Pinus* pollen values to about 45%. This zone is characterized by the great diversity of herbaceous pollen taxa. Besides dominating *Cyperaceae* and *Gramineae*, heliophytes are quite abundant, including *Caryophyllaceae, Chenopodiaceae*, and *Compositae*. Moreover, the values of *Cruciferae, Thalictrum* and *Selaginella selaginoides* are markedly higher than in other zones. *Ephedra fragilis* and *Armeria* also occur regularly (not indicated on the simplified diagram in Fig. 3). This composition of pollen spectra suggests the regeneration of open tundra-type vegetation on the studied area.

Thus, the described pollen zone MII–7 would correspond to the new stadial.

The following zone in the pollen diagram (MII–8) records the phase of forest development. It is characterized by the contribution of *Pinus* pollen amounting to about 40%, and also increased *Betula, Alnus* and *Picea* pollen values (12%, 3% and 3%, respectively). Among the herbaceous pollen taxa the contributions of *Cyperaceae* and *Gramineae* decrease in comparison with those in the preceding zone. Simultaneously, the *Artemisia* pollen curve increases. During the interstadial represented by this zone the trees spread again in the study area and formed open park-like forests. This interstadial is most likely analogous with the Odderade (Behre 1989).

The following zone MII–9 represents a short-lasting cooling which is recognised as a next stadial. Its characteristic feacture is the dominance of *Cyperaceae* (about 60%) with subdominant *Gramineae* (3.5%) and *Artemisia* (1.5%). The contributions of *Pinus* and *Betula* decrease to about 20% and 8% respectively, suggesting another period of forest recession. The pollen grains from deciduous trees found in this zone are probably redeposited.

The pollen zone MII–10 is characterized by the slightly increased frequencies of tree pollen, mainly *Pinus* (about 30%) and *Betula* (about 12%), when compared to those in the preceding zone. The percentage of NAP (about 45%) including mainly *Cyperaceae*, is also relatively higher. This zone is characterized by the large amounts of redeposited pollen grains of pre-Quaternary origin what may suggest that the pollen of thermophilous trees present in this zone in abundance comes also from a reworked deposit. This zone may possibly correspond with a new interstadial. However, as shown by pollen spectra, the climate of this period with relatively low temperatures prevented the development of dense forest. The vegetation was of parkland type, with trees forming loose groupings within open grasslands or along the rivers.

In the sediment above the MII–10 zone the pollen frequency is very low. The interpretation of pollen spectra is additionally hindered by the high contribution of the rebedded, undetermined and corroded pollen grains. The analysis of this profile section will be subject to further studies.

THE LATE VISTULIAN

The late glacial succession of vegetation was described on the basis of the bottom part of pollen diagram MI comprised between the depth of 4.00 m and 2.95 m (Fig. 4).

The lowest series of samples (pollen zone MI–1) (4.00–3.90 m) is characterized by the relatively high percentage of *Pinus* and *Betula* pollen (40% and 30% resp.). These trees formed probably loose patches of forest among the shrub (*Betula cf. nana, Hippophae rhamnoides, Salix*) and herb (*Artemisia, Chenopodiaceae, Caryophyllaceae*) communities. This period is likely to represent the first late-glacial climatic warming called Bølling.

In the pollen zone MI–2 the values of NAP (mainly *Cyperaceae*, *Gramineae*, *Artemisia*) and shrub pollen (*Betula cf. nana*, *Salix*, *Hippophae*) increase to about 50%. The variety of herb pollen taxa, such as *Anemone*, *Helianthemum*, *Saxifraga oppositifolia* type, *Aster* type, *Gypsophila fastigiata*, *Anthemis* type and *Thalictrum* is of regular occurrence. Such composition of pollen spectra suggests the vegetation of tundra type with dwarf shrubs and a small contribution of pine and birch trees. Thus, the zone seems to correspond with the Older Dryas cooling (Pawlikowski et all 1982, Bałaga 1982). The short-term sudden increase in the tree pollen (mainly *Pinus*) values between the 3.775 m and 3.65 m levels is probably connected with the abundance of rebedded material and can not be interpreted as a climatic oscillation.

The next pollen zone of the Late Glacial (MI–3) is characterized by the higher contribution of tree (especially *Pinus*) pollen. At its onset the curve of *Hippophae* pollen declines. The pollen curves of other shrubs decrease slightly too, and the curves of *Cyperaceae* and *Gramineae* decrease quite markedly. The contribution of *Artemisia* and other herbaceous plants remains more or less unchanged. At that time the area surrounding Machnacz peat-bog was most likely overgrown by pine-birch forests. There were, however, frequent openings with herb and shrub vegetation among patches of the forest. The correlation of this diagram-section with the Allerød time seems probable (Bałaga 1982).

The last phase of the Late Glacial, described on the basis of the pollen zone MI–4, is likely to correspond to the Younger Dryas. The landscape featured some pine-birch forests, which, however, occupied much reduced areas. On the other hand, steppe-like communities of juniper (about 15% in the total pollen) and heliophyte herbs were more widespread.

HOLOCENE

The boundary between the Late Glacial and Holocene is delimited by the almost complete decline of shrubs (*Betula cf. nana*, *Juniperus*) and heliophytes, and the marked increase in the curve of *Pinus* pollen. In the sediment this boundary corresponds with the transition between gyttja and brown moss-peat, and because of it the pollen spectra of the first Holocene pollen zone (MI–5) are highly influenced by the local pollen inflow. Its pollen composition is characterized by the abruptly increased pollen values of *Cyperaceae* (to ca. 40%) and *Gramineae* (to about 15%). The pollen percentages of *Pinus* and *Betula* are relatively low and oscillate between 20% and 40%.

The pollen zone MI–6 is represented by the layer of a little decomposed peat 1 m thick. During the period corresponding to this zone pine-birch forests predominated. The zone has been subdivided into two subzones. During the older subzone (MI–6a) the role of shrub (*Salix*) and open herb communities was still substantial, and participation of *Pinus* slighly higher than that of *Betula*. The dominance of *Betula* in the younger subzone (MI–6b) may be of local importance. During this period, as peat analysis shows, *Sphagnum* bog was abundantly overgrown by trees and shrubs with dominant *Betula* (Żurek 1989a). Thus, the part of birch pollen might have originated from the trees growing in this community. Another distinguishing feature of the younger subzone is a continuous pollen curve of *Ulmus*, and regular appearance of other deciduous trees of *Corylus*, and *Picea*.

The following period is represented by the pollen zone MI–7. In the pollen spectra *Pinus* pollen predominates over *Betula* again. The values of *Corylus* increase from 2%, at the beginning of the zone, to about 13% at its end. *Ulmus* pollen curve oscillates around 3%. Evidently, the dominant forest communities were pine forests with a relatively high contribution of hazel and a little contribution of deciduous trees (elm, alder, lime and oak) and spruce.

In the zone MI–8 *Pinus* and *Alnus* are dominant pollen types. *Betula* pollen values are lower that in MI–7 zone. At the base of zone *Corylus* pollen curve decreases from about 15% to about 10%. *Ulmus*, *Tilia* and *Quercus* pollen curves rise gradually, reaching several percent values each. The sum of herbaceous pollen taxa is the lowest of all the zones (below 5%).

Such composition of pollen spectra indicates that the mixed deciduous forests reached their maximum Holocene developement in the investigated area at that time.

The zone MI–9 is characterized by *Pinus* pollen values decreasing from 50% to 35%. The *Alnus* pollen values stabilize at about 15–20%. *Betula* pollen values are lower (10–15%) than those in MI–8. *Ulmus* pollen curve oscillates between 0.5 and 3%, that of *Corylus* between 10 and 15%. *Carpinus* and *Fagus* pollen are present continuously, the latter rising slightly in the upper part of zone. *Tilia* percentages decrease more gradually. NAP values amount to about 5%, and *Cerealia, Rumex acetosella, Plantago lanceolata* pollen occurs sporadically indicating some human settlements in the surrounding areas. During the period represented by this zone deciduous forests became more open and dominated by oak with abundant hazel undestorey, what may also be connected with the activities of prehistoric (Neolithic?) man.

In the zone MI–10 *Pinus* proportion rise slightly to about 45%. At the base of zone *Corylus* pollen values decrease steeply to about 12%, and later, gradually to about 2%. The values of *Ulmus, Tilia* and *Quercus* pollen also decrease, while the curve of *Carpinus* and NAP (*Ericaceae, Gramineae, Artemisia*) values rise.

The zone MI–11 is generally distinguished by the *Carpinus* pollen percentage being much higher that in MI–10 but highly variable. The zone may be divided into three subzones. Among them, the first (MI–11a) and the third one (MI–11c) are characterized by the increased values of *Carpinus* (about 6%) and the small peaks of *Picea, Tilia* and *Quercus*. The middle subzone (MI–11b) is characterized by the depressions of all the above mentioned tree pollen curves and the rise in NAP pollen values with dominant *Ericaceae*. This zone represents the last period of the existence of mixed deciduous forests in this area. It consists of two phases of forest regeneration separated by the phase of extensive deforestation and strong cultural impact.

In the zone MI–12 the pollen curves of all trees, except for *Pinus* and *Picea*, are very low. *Pinus* pollen values rise to 30%. NAP values are high, rising throughout to about

30%. Among NAP, *Gramineae* and *Cerealia* and later also *Artemisia*, *Chenopodiaceae* and *Rumex*, are the dominant pollen types. This zone represents the almost complete deforestation and the formation of the cultural landscape around the Machnacz peat-bog.

The presented results of pollen analysis, despite very irregular sedimentation, appear to correlate well with general Holocene pattern of vegetational development in NE Poland (Ralska-Jasiewiczowa 1966; Pawlikowski et all 1982, Balwierz & Żurek 1987). On the other hand, the development of vegetation at the beginning of Holocene (MI–5 and MI–6 pollen zones) will require further palynological studies supplemented by macrofossil analysis and C–14 dating to find out how far the record obtained is influenced by the local plant succession.

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REFERENCES

BALWIERZ Z. & ŻUREK S. 1987. The Late-Glacial and Holocene vegetational history and paleohydrological changes at the Wizna site (Podlasie Lowland). Acta Palaeobot., 27 (1): 121–136.

BAŁAGA K. 1982. Vegetational history of the Lake Łukcze environment (Lublin Polesie, E. Poland) during Glacial and Holocene. Acta Palaeobot., 22 (1): 7–22.

BEHRE K. E. 1989. Biostratigraphy of the last glacial period in Europe. Quat. Sci. Rev., 8: 25–44.

BITNER K. 1954. Charakterystyka paleobotaniczna utworów interglacjalnych w Horoszkach koło Mielnika na Podlasiu (summary: The palaeobotanic characteristic of the interglacial deposits at Horoszki near Mielnik in Podlasie). Biul. Inst. Geol., 69: 79–91.

— 1956. Nowe stanowiska trzech plejstoceńskich flor kopalnych (summary: Three new localities of Pleistocen flora). Biul. Inst. Geol., 100: 247–262.

— 1957. Trzy stanowiska flory interglacjalnej w okolicach Sidry (summary: Three localities of interglacial flora of Sidra, northly of Sokółka in Polesie). Biul. Inst. Geol., 118: 109–154

BORÓWKO-DŁUŻAKOWA Z. 1973. New localities with Eemian flora in the Polish Lowland. In: Palinologiya Pleystotsena i Pliotsena. Nauka, Moskwa.

— 1974. Eemska flora z Klewinowa na Nizinie Podlaskiej (summary: Eemian flora at Klewinowo in the Podlasie Lowlands). Biul. Inst. Geol., 269: 11–22.

DĄBROWSKI M. J. 1959. Późnoglacjalna i holoceńska historia lasów Puszczy Białowieskiej. Acta Soc. Bot. Pol., 28 (2): 197–248.

GALON R. & ROSZKÓWNA L. 1967. Zasięgi zlodowaceń skandynawskich i ich stadiałów recesyjnych na obszarze Polski. In: Czwartorzęd Polski. Galon R. & Dylik J. (eds.). PWN, Warszawa.

JASTRZĘBSKA-MAMEŁKA M. 1985. Interglacjał eemski i wczesny Vistulian w Zgierzu-Rudunkach na Wyżynie Łódzkiej (summary: The Eemian Interglacial and the Early Vistulian at Zgierz-Rudunki in the Łódź Plateau). Acta Geogr. Lodz., 53: 1–75.

MAMAKOWA K. 1989. Late Middle Polish Glacition, Eemian and Early Vistulian vegetation at Imbramowice near Wrocław and the pollen stratigraphy of this part of the Pleistocene in Poland. Acta Palaeobot., 29 (1): 11–176.

PAWLIKOWSKI M., RALSKA-JASIEWICZOWA M., SCHÖNBORN W., STUPNICKA E. & SZEROCZYŃSKA K. 1982. Woryty near Gietrzwałd, Olsztyn Lake District, NE Poland – vegetational history and lake development during the last 12 000 years. Acta Palaeobot., 22 (1): 85–116.

RALSKA-JASIEWICZOWA M. 1966. Osady denne Jeziora Mikołajskiego na Pojezierzu Mazurskim w świetle badań paleobotanicznych (summary: Bottom sediments of the Mikołajki Lake (Masurian Lake District) in the light of palaeobotanical investigations). Acta Palaeobot., 7 (2): 1–118.

ŻUREK S. 1989a. Stratygrafia, rozwój i kierunki sukcesyjne torfowisk strefy wododziałowej w Puszczy Knyszyńskiej. (in print).

— 1989b. Wyjaśnienie sytuacji chronostratygraficznej i geomorfologicznej w okolicy torfowiska Machnacz (etap wstępny) – Komitet Badań Czwartorzędu. MS.

— 1990. Związek procesu zatorfienia z elementami środowiska przyrodniczego wschodniej Polski. Roczniki Nauk Rolniczych, ser. D, Monografie, 220.