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GEOLOGIC SETTING AND POLLEN ANALYSIS OF INTERGLACIAL ORGANIC SEDIMENTS AT MOKRANY NOWE IN PODLASIE, EASTERN POLAND

Sytuacja geologiczna, warunki akumulacji i analiza pyłkowa interglacjalnych osadów organogenicznych w Mokranach Nowych na Podlasiu.

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ABSTRACT. At Mokrany Nowe in Podlasie, within the extents of the Odra and presumably also Warta glaciations, organic sediments without any till cover were noted. Preliminary pollen analyses of single samples from bituminous shales and peats from three boreholes speak for their connection with the Mazovian Interglacial of the Biała Podlaska i.e. Krępiec floristic sequence. Biostratigraphic conclusions disagree with the present ideas on extents of the Middle-Polish Glaciations in this part of Poland and interpretation of geologic and geomorphologic setting of the studied sediments.

KEY WORDS: pollen, Eemian interglacial, Podlasie

INTRODUCTION

During geologic studies in southeastern Podlasie a site with shales, organic silts and peats up to 3 m thick was noted at Mokrany Nowe, 15 km to the northwest from Terespol (Fig. 1). Preliminary palynologic investigations indicate an interglacial origin of the sediments. The paper presents geologic geomorphologic setting of these organic sediments as well as results of palynologic studies and postulated age.

GEOLOGIC AND GEOMORPHOLOGIC SETTING

The side of Mokrany Nowe is located on a morainic plateau in a small depression at 150 m a.s.l. About 2 km to the east from the site there is a Valley of the Krzna River, a bottom of which runs at 129–131 m a.s.l. in this area. A plateau surface with hillocks up to 10 m is composed mainly of till with small hills of glacial sands, gravels and boulders.

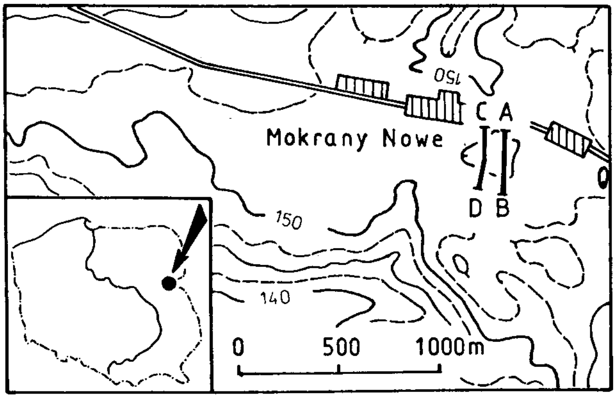

Fig. 1. Location sketch of Mokrany Nowe area with marked geologic sections A–B and C–D

Studies of the extent of the Warta Glaciation (sensu Lindner 1988) in this area are predominated by two different opinions what makes the age of this plateau till uncertain. According to Nowak (1977), Baraniecka (1984) and Falkowski et al. (1984–85) this till and gravel hills (concidered for end moraines) come from Warta Glaciation (Stade?). Różycki (1972), Rühle (1973) and Lindner (1988) connect these features with the Odra Glaciation (Stade?) and locate a maximum extent of the Warta Glaciation several kilometers to the north near Krynica.

Two parallel geologic sections across two alongated depressions (Figs 1, 2) with organic sediments were constructed from collected borehole sections. The depressions are to 40 m wide, 150 m long and to 4 m deep (Fig. 2). They are formed in grey and sandy till (layer 1). The till is locally overlain by medium-grained sands with gravel (layer 2), partly clayey and passing into blue-gray clays 1 m thick (layer 3), covered in turn by flow till 0.5 m thick (layer 4). This till is overlain by thin series of grey clays with organic matter in the top (layer 5). Organic deposition is preceded by medium-grained grey-black sands (layer 6) capped with 20 cm thick tree trunk (Fig. 2). Above there are black bituminous shales (layer 7) with local admixture of sands. In the borehole MN 5/90 the shales are slightly inclined in the bottom (Fig. 2).

Vari-grained sands with gravel that overlie the bituminous shales, contain also crashed fragments of shales (layer 8). Similar sediments were also noted in boreholes MN 1/89 and MN 2/89 (Fig. 2). In the section C–D sands with shales fill an erosive incision in shales and in the section

A–B they are partly overlain by sands with gravels (layer 9) coming from slopes of the depression. Further deposition is expressed by grey-green silts (layer 10) and well decomposed brown and locally sandy peats (layer 11). Peats and surrounding toills are overlain by clayey fine-grained sands, passing into medium-grained ones with gravel and covered locally by a thin series of clays (layer 12 and 13). These sands are overlain by fine-grained and medium-grained yellow sands of glaciofluvial origin (layer 14).

Incisions in central parts of depressions are filled by up to 2 m thick sands and gra-

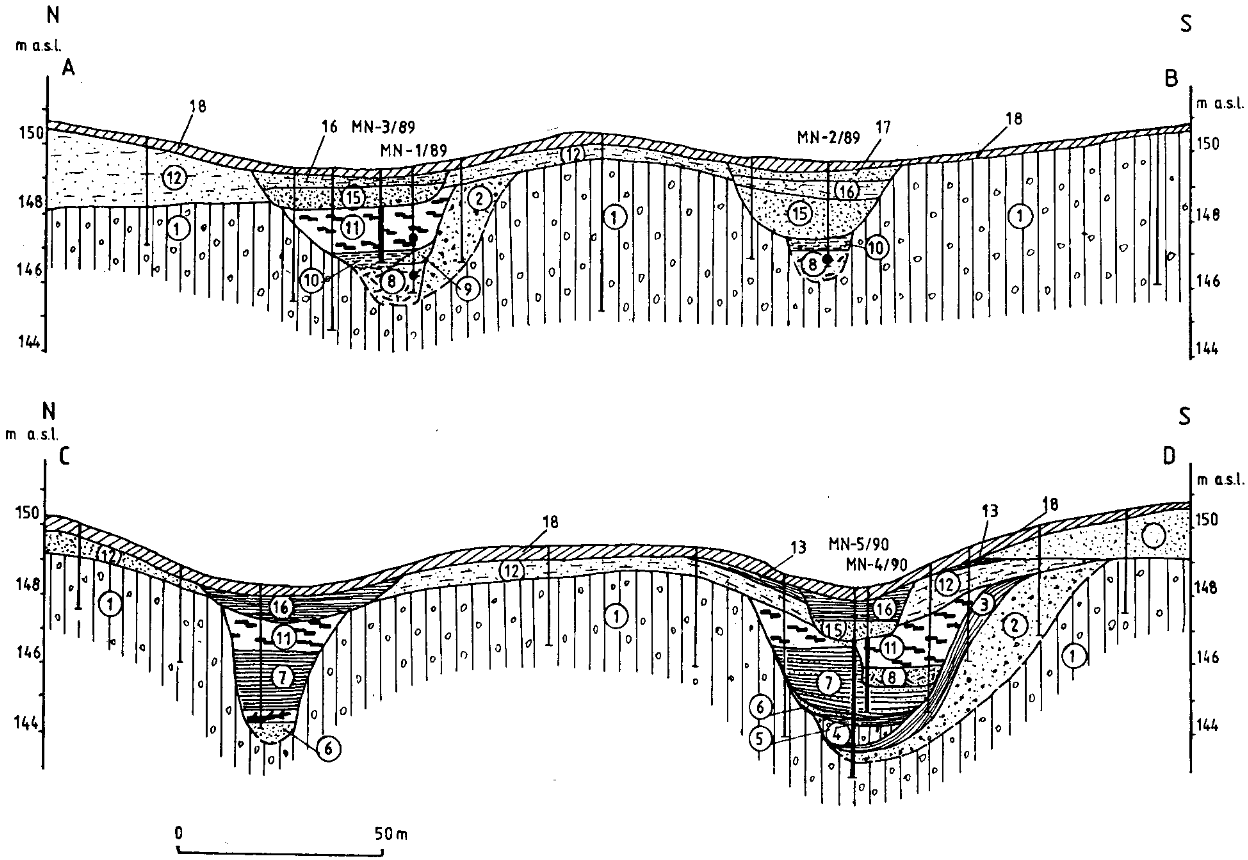

Fig. 2. Geologic section A–B and C–D across the site of organic sediments in Mokrany Nowe area. Thicker fragments of sections and dots point sampling to palynologic analyses. 1 – till, grey and sandy, 2 – clayey medium–grained sands with gravel, 3 – blue-grey clay, 4 – flow till, grey and sandy, 5 – grey clay, 6 – grey-black medium-grained sands, 7 – bituminous black shales, locally sandy, 8 – vari–grained sands with gravel, with crashed and organic matter, 9 – sands with gravel, 10 – grey–green silts, 11 – peat, 12 – fine–grained and medium–grained sands, partly silty, 13 – sandy clays, 14 – fine-grained and medium-grained yellow sands, 15 – sands with gravel, 16 – clayey fine-grained sands passing into clays, 17 – medium–grained sands, 18 – soil

vels (layer 15) and clays (layer 16). The latter are sandy in the section A–B. In the top there are medium-grained sands (layer 17; Fig. 2). All these sediments are capped with a soil (layer 18), composed of humus sands or peat.

POLLEN ANALYSIS AND BIOSTRATIGRAPHY

Palynologic studies of organic sediments from Mokrany Nowe have been carried through in several phases and in different terms. First samples were collected in August 1989 (boreholes MN 1/89 and MN 2/89; Figs 3, 4). Preliminary results were found very interesting but did not allow a univocal dating of the sediments. In October 1989 samples in a new borehole MN 3/89 were collected (Fig. 5). Certain discrepanties between geologic and paleobotanic conclusions on age of deposition made the authors go on with field works and palynologic studies. In March 1990 eleven samples were collected from the borehole 4/90 (Fig. 6) and in July 1990 a full core of organic sediments (borehole MN 5/90), a pollen analysis of which has not been done yet. Interpretation of results follows the turn of collection of samples for paleobotanic analyses.

At least 500 tree pollen (AP) and other sporomorphs and other microorganisms noted in the same time were counted in individual samples. Taxons which were noted during an extra examination of a sample but not during the conventional counting were marked with + if one specimen, or with x – if two or more. Percentage contents of individual taxons were defined against a basal total, being the one of tree pollen (AP) as well as grass and bush pollen (NAP) but without the ones of rush, water and cryptogamic plants, *Pediastrum*, varia and destructed. Their contents were also defined against this total.

Mokrany Nowe MN 1/89

Two samples from this section were analyzed (Fig. 3). The sample 2 (depth about 3 m) is prominated by pollen of *Betula* (83.5%), quite numerous *Salix* (1%). There are low values of *Pinus* (0.7%) and *Picea* (0.2%). Participation of NAP relatively low (14.7%), mainly (2.3%) and *Gramineae* (7.6%), *Juniperus* (3.5%), *Cyperaceae* (2.3%) and *Artemisia* (0.5%). Other herbs and bushes are rare and contents of their pollen very low (*Hippophaë, Chenopodiaceae, Compositae Liguliflorae, Ranunculus acer* type and *Thalictrum*). Three other taxons should be mentioned i.e. *Sparganium – Typha angustifolia* amidst rush plants, *Polygonum amphibium* admist water plants and *Equisetum* (2%) admist cryptogamic plants. Pollen spectrum of this sample has pure Quaternary features. No spore of exotic or Tertiary plants were noted. Thus the pollen is of local origin and vegetation cover considerably eliminated effects of denudadion in the area.

Quantitative relations between the taxons and their variation make a pollen spectrum reflect quite compact birch forest or its numerous patches. Areas outside such community could be occupied by juniper, especially where low ground waters occurred. In wet zones could quite abundand willow bushes develop. Values for pollen of *Pinus* and *Picea* do not speak for presence of these trees. Such low contents of pine pollen in spec-

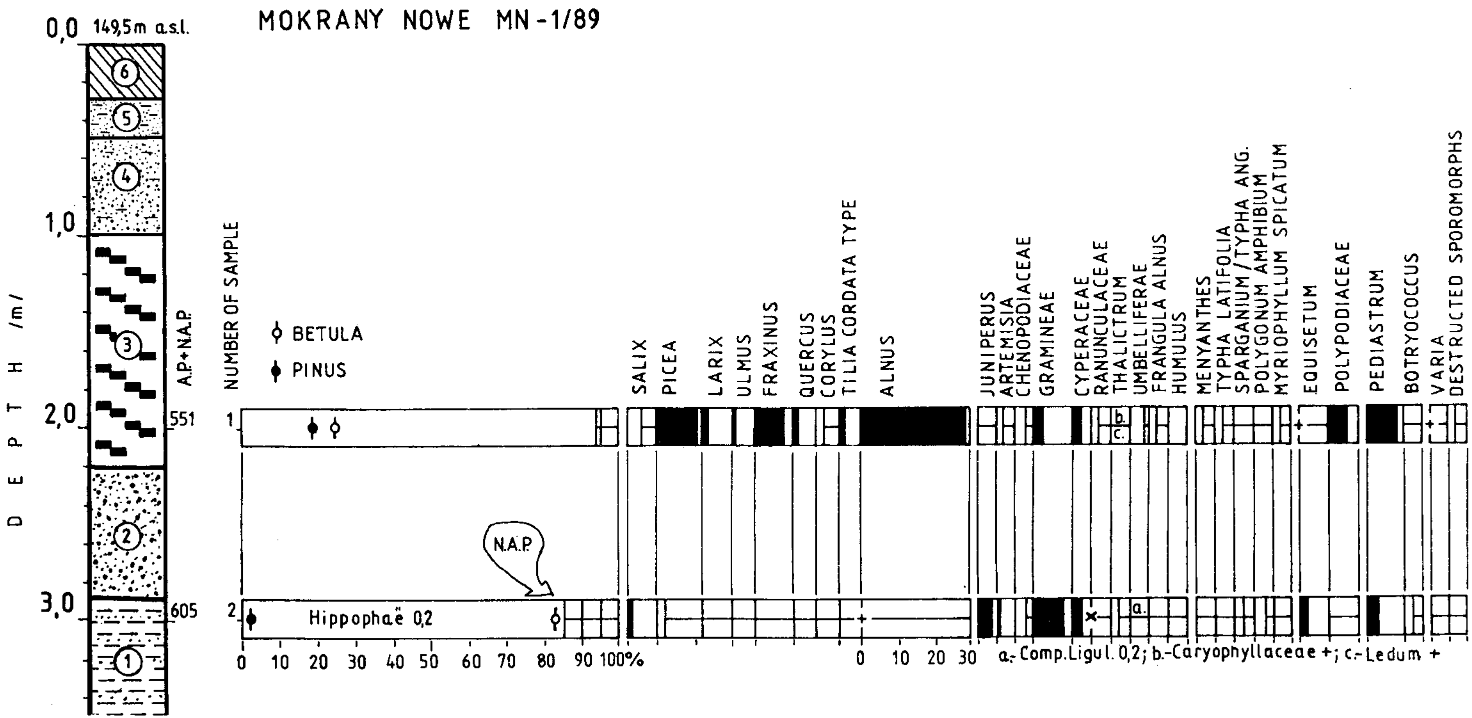

Fig. 3. Mokrany Nowe MN–1/89, pollen diagram. 1 – silt, 2 – sand with gravel, 3 – peat, 4 – medium-grained clayey sand with single gravel, 5 – clayey fine-grained sand, 6 – soil horizon A1

trum with so distinct climatic expression is somewhat astonishing. Even in numerous and lithologicaly similar samples from a protointerglacial phase of Krępiec-type (Janczyk-Kopikowa 1981) or Biała Podlaska type (Krupiński 1984–85, 1988a, Krupiński et al. 1986, 1988) its content is higher. In the site Komarno, a flora of which is ismilar to the one of Biała Podlaska (Krupiński & Lindner 1988, 1990, Krupiński et al. 1988), pollen spectra of this part of the sequence indicate also such low values of this pollen. Slight variation of low values of *Pinus* pollen in these neighboring sites is undoubtedly of local character and can be explained by insufficiently dense sampling of sediments in the site of Biała Podlaska.

Pollen spectrum of the sample 1 (depth about 2 m) indicates quite a rich flora with numerous *Alnus* (28%), *Betula* (24%), *Pinus* (18%), *Picea* (11%), *Fraxinus* (7%) and occasinally *Larix* (1%). Considerable contents of pollen of other deciduous trees were noted – they were of slightly higher demands: *Tilia cordata* type (1.3%), *Ulmus* (1.4%) and *Corylus* (0.2%). Low values of herbs and bushes (about 6%) and presence of taxons connected with well developed mixed forests (*Frangula alnus, Humulus*) prove that depending on habitats such forests with varying genera have really existed.

Wet areas were presumably occupied by compact alder communities, possibly with birch. Miost areas were covered by the already mentioned trees also by spruce and ash, and rare larch and elm. Other habitats were occupied by spruce, ash, elm, linden and oak. Forest communities on sunny edges could occasionally contain hazel. Dry zones were probably overgrown by pine and verrucose birch.

Pollen spectra from the two samples from Mokrany Nowe against quite well known vegetation of Krępiec-like i.e. Biała Podlaska or Komarno (Krupiński 1988a) interglacial sequence from this part of Poland, enables to correlate the sample 2 (depth about 3 m) with a middle or younger part of the pollen horizon BP–A *Betula* –NAP – *Salix* – *Juniperus* or Km–A, the sections from the site Biała Podlaska (Krupiński 1984–85, 1988a, Krupiński et al. 1986, 1988) or Komarno (Krupiński & Lindner 1988, 1990). Lower contents of *Pinus* and NAP if referred to the sections from Biała Podlaska are insignificant and can result from varying local habitats and pollen rain. Presence of the same taxons and similar quantitative relations create also an important comparability criterion.

Pollen spectrum of the sample 1 (depth about 2m) is considerably similar to the ones of the middle part of the pollen horizon BP–C *Picea-Alnus* (*Pinus-Betula*) from Biała Podlaska and Komarno. Insignificant difference expressed by slightly greater content of *Fraxinus*, especially if referred to the site Biała Podlaska, is of local origin and can reflect varying habitat conditions.

As pollen spectrum of the sample 2 is almost the same as of the middle and younger part of the pollen horizon BP–B from the site Biała Podlaska or Komarno (Km–B) whereas pollen spectrum of the sample 2 is similar to the middle part of the horizon BP–C or KM–C in both mentioned sites, they seem to be of the same age. Pollen spectra from Mokrany Nowe are not similar to the ones from other interglacials. Therefore, the sample 2 probably represents a proto-interglacial part and the sample 1a beginning of the Mazovian Interglacial with Krępiec-like sequence i.e. of Biała Podlaska and Komarno. Such opinion is also supported by palynologic studies of the sample from the neighboring borehole MN–2/89, depth about 2.7 m.

Mokrany Nowe MN – 2/89

This sample is composed of fine-grained organic matrial (decomposed peat) mixed with coarse-grained material (sand, gravel and even fine boulders). Such features of the sediment made the sample be subdivided into smaller ones, depending on predominating component. From these smaller samples with larger contents of organic (peaty) matter, material for pollen analysis was separated three times whereas from the one with more mineral (sandy) contents – only once.

Pollen spectra (Fig. 4) from three subsamples of the peaty material contained much *Abies* (about 17%) and *Carpinus* (about 5%). Sandy subsample has distinctly different spectrum with much *Picea* (36%) more than in other interglacial floras of the Krępiec sequence in this part of Poland (Krupiński 1984–85, 1988, Krupiński et al. 1986, 1988. There is also abundant *Alnus* (27%), quite a lot of *Taxus* (2.3%), less *Ulmus* (1.4%), *Quercus* (1.3%), *Tilia cordata* type (1.5%), *Fraxinus* (1.1%), *Corylus* (1.1%) and rare *Hedera, Viscum, Nuphar, Nymphaea* and microsporangium of *Azolla filiculoides*. No single pollen of *Abies* and *Carpinus* was noted. The organic subsamples seem to come from the communites of fir-hornbeam forests with oak and abundant pine, and in wet habitats – with alder. These spectra are to be referred to a final part of the interglacial of the Biała Podlaska sequence or to an interstadial post-interglacial warming (Krupiński 1988b). Sandy subsample represents development of spruce forest and alder communities. Such forest with appearing yew presents a younger part of the pollen horizon BP–D *Picea-Alnus* (*Pinus-Taxus*) from the older part of interglacial sequence of the Biała Podlaska type (Krupiński 1988a).

Age variation of sediments from this single sample is to be explained by their deformations or incorporation of upper organic sediments into lower one during drilling. The later is possible due to a use of ordinary auger. Good and detailed recognition of local and regional features of interglacial flora of the Biała Podlaska (Komarno) sequence on the basis of eleven sections from the site Biała Podlaska and Komarno, distinctly enabled age evaluation of flora at Mokrany Nowe, even if basing on two occasional samples from slightly diagnostic floristic horizons of the section MN–1/89. In this site the diagnostic features are comprised firstly in the pollen specrtum of the sample 1, containing much pollen of *Picea* and *Alnus*, and other taxons. The age evaluation was much simpler due to results of pollen analysis of the sample from the neighboring borehole MN–2/89 where abundant pollen of *Abies* and *Carpinus*, and single microsporangium of *Azolla filiculoides* were noted.

Flora of the Mazovian Interglacial with the Biała Podlaska sequence indicates an early, almost simultaneous appearance and climax of *Alnus* and *Picea* with considerably lower values of *Pinus* and *Betula* and low contents of *Fraxinus, Quercus, Ulmus* and *Tilia*. Linden comes relatively early in this interglacial but it has not reached significant values in pollen spectra from this part of Poland. Sequences of plant communities from other interglacials are in this case considerably different. It seems doubtful that the ana-

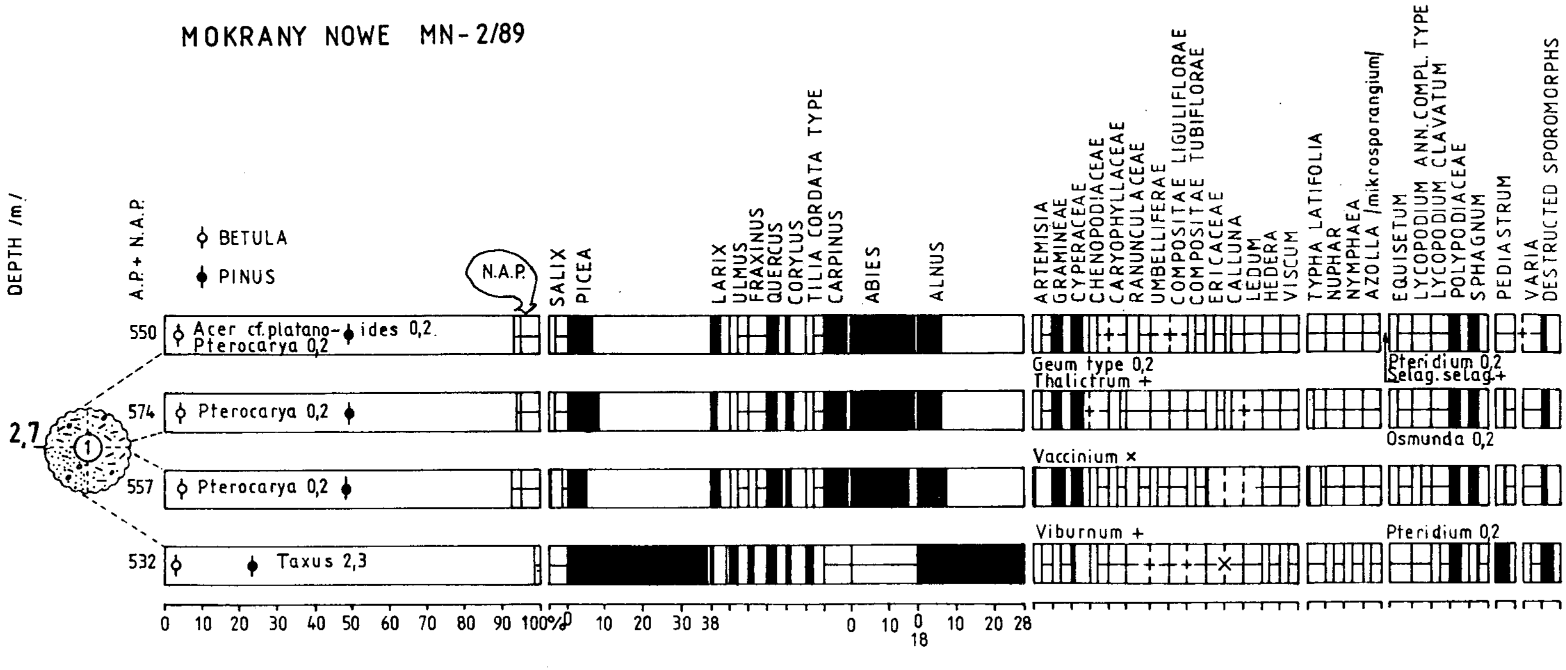

Fig. 4. Mokrany Nowe MN–2/89, diagram of four pollen spectra of a sample from depth of 2.7 m. 1 – vari-grained sands with gravel, with clashed bituminous shales and organic matter

lyzed flora from the site Mokrany Nowe comes from any of these interglacials. It indicates many and as pointed out, most common features with interglacial flora of the Biała Podlaska sequence.

Such biostratighraphic conclusions on organic sediments from Mokrany Nowe considerably disagree with the present opinions on extents of the Middle-Polish Glaciations in this part of Poland as well as geologic and geomorphologic interpretation of the studied sediments by one of the coauthor of this paper. Mokrany Nowe are certainly within the extents of the Odra Glaciation and according to Falkowski et al. (1984–85, 1988), Nowak (1977) and Baraniecka (1984), also of the Warta Glaciation. Sediments of any pre-Eemian interglacial should be overlain by at least a single till or its residuum. Absence of glacial sediments or their residuum above organic series speaks for a younger age than the last glaciation in this area. In this way a principal discrepancy between the conclusions from palynologic investigations and geographic setting of interglacial sediments arises. The author of paleobotanic studies does not exclude a possible destruction of overlying glacial sediments due to later erosive-denudation processes, particularly in a periglacial environment.

Divergence of conclusions made the authors to collect another, possibly complete borehole of organic sediments from this site and to carry through further works on presence or absence of glacial sediments or their residua.

Mokrany Nowe MN–3/89

14 samples were collected for palynologic investigations (Fig. 5). Results of analyses of four samples of silts from under organic sediments (depth 2.2–2.7 m) were negative to absence of floristic remains. Analyses of other 10 samples of organic sediments enabled to distinguish three pollen horizons that comprise a sequence that is also represented by both samples from the borehole MN–1/89.

Pollen horizon MN–3–A *Betula-Juniperus* (*Salix-Pinus*), samples 7–10, depth 1.7–2.2 m, is represented by totally decomposed peat, clayey at the bottom, and underlain by decalcified grey and grey-blue silt. This material is poor in pollen in the bottom but contains much of them in the top. Pollen spectrum contains *Betula* (72–60% in the bottom and 60% in the top), *Pinus* (3–20%), *Salix* (1.3–0.4%). There is a lot of NAP (27–17%), mainly *Gramineae* (11–8%), *Cyperaceae* (5–2%), *Juniperus* (9–5%), *Hippophae* (0.7–0.1%), and among others *Artemisia, Chenopodiaceae, Thalictrum, Umbelliferae, Ranunculaceae*. Pollen spectra from the lower part of this horizon contain however an insignificant content of pollen of exotic plants and of specimens of *Hystrichosphaeridium*. Total content of the material on a secondary deposit was estimated for obout 1% – these spectra are therefore almost entirely of Quaternary derivation.

Pollen horizon MN–3–B *Betula-Pinus-Larix* (*Picea-Alnus*), samples 5–6, depth 1.5–1.7 m, is composed of well decomposed peat with good and very good content of very well preserved pollen. Pollen spectra contain quite a lot of taxons: but the predominating pollen of *Betula* (49–42%), rising *Pinus* (31–36%) there are considerable contents of *Larix* (about 2%), *Picea* (1–8%), *Alnus* (1–5%), *Ulmus* (about 1%), *Fraxinus* (about 1%), *Quercus* (to 0.5%) and occasionally *Tilia cordata* type. Participation of NAP has distinctly decreased (to about 8–10%). Entrance of *Humulus* is noted. No exotic or Tertiary sporomorphs occurred.

Pollen horizon MN–3–C *Picea-Alnus* (*Pinus-Betula*), samples 1–4, depth 1.1–1.5 m, is formed of decomposed peat, conciderably clayey in the top. It indicates of well preserved pollen. Pollen spectra contain numerous taxons with almost all (but *Abies*) our home trees and occasionally in the sample 3, a single pollen of *Pterocarya*. Pollen spectra are predominated by *Alnus* (18–34%), *Picea* (9–20%) and still high contents of *Pinus* (35–21%), decidedly lower of *Betula* (31–14%) and increasing of *Fraxinus* (2–3%), *Tilia* (to 2%), *Quercus* (about 1%), *Ulmus* (to 2%) and *Corylus* (to 1%). Pollen of *Acer* and *Carpinus* appeared, and in the uppermost sample a single pollen of *Abies*. This last taxon does not seem to be important as can be due to contamination of the sample. Participation of NAP is insignificant and equal about 4%, only in the lowest sample reaching 8%. But a single spore of *Ephedra distychya* type (sample 2) no pollen of open country vegetation was noted.

A slightly higher location of the lower border of this horizon and of the upper of the previous one i.e. between the samples 3 and 4 (depth 1.4 m) seems also reasonable.

Pollen spectra of the distinguished three pollen horizons comprise a vegetation sequence connected with development of primary communities, firstly of non-forest or forest ones of insignificant density and then of forest ones coming from a beginning of the interglacial.

The pollen horizon MN–3–A *Betula-Juniperus* (*Salix-Pinus*) reflects development of pioneer plant communities, only partly forest ones or forest ones but with slight compactness, with birch as the main component, abundant juniper, pine and seabuckthorn. Open habitats were overgrown with grasses, *Cyperaceae*, *Artemisia* and other herbs and bushes of higher light demands included. Relatively poor overgrowing of surface deposits make it possible that accumulation of that time was accompanied by deposition of pre-Quaternary sporomorphs, coming from older destructed and redeposited sediments.

Pollen horizon MN–3–B *Betula-Pinus-Larix* (*Picea-Alnus*) indicates development of first dense forest communities that finish a protocreative phase of interglacial flora. Quite compact communities of pine-birch forests with appearing and quickly rising spruce, alder, larch, elm, ash and oak. Participation of juniper and of other plants with greater light demands was distinctly limited and they completely disappeared at the end of this horizon. Elm, ash and associated hop were important components of forests.

Pollen horizon MN–3–C *Picea-Alnus* (*Pinus-Betula*) records a well developed process of created dense forest communities, varied depending on habitat conditions. The highest areas with a lowest ground water level were probably further occupied by pine forests with birch. Most areas were overgrown with abundant spruce, wet and periodicly flooded zones that could be relatively more common, belonged to alder communities, presumably with elm and ash. Areas with edaphicly most favorable conditions and with suitable water relations possessed forests with ash, oak, linden and occasionally with maple and hornbeam, on sunny escarps also with hazel.

Detailed comparison of distinguished pollen horizons in the section Mokrany Nowe MN–3/89, either if taxons or if quantitative relations between them are taken into ac-

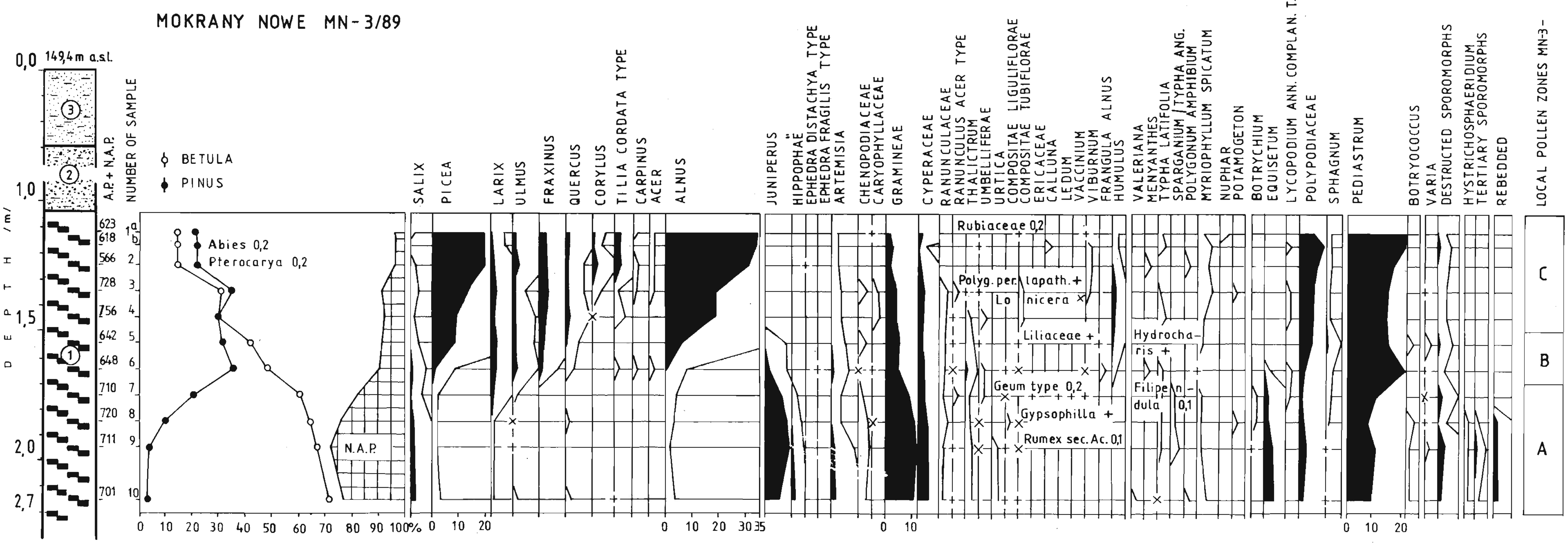

Fig. 5. Mokrany Nowe MN–3/89, pollen diagram. 1 – peat, 2 – sand with gravel, partly clayey, 3 – fine-grained clayey sand

count, enabled to correlate the pollen horizon MN–3–A with the horizon BP–A in the sections of the site Biała Podlaska (Krupiński 1984–85, 1988a, Krupiński et al. 1986, 1988) and with Km–A at Komarno (Krupiński in prep., Krupiński & Lindner 1988, 1990) whereas the pollen horizon MN–3–B with BP–B, and MN–3–C with lower and upper part of a similar horizon in the mentioned sites. However the pollen horizon MN–3–C cannot comprise a full floristic sequence, represented by pollen horizons BP–C or Km–C in the sites Biała Podlaska or Komarno, as no first traces of yew pollen (younger part of the horizon BP–C or Km–C) are noted there.

Results of palynologic studies of sediments from the section MN–3/89 supported the previous biostratigraphic conclusions, drawn already on the basis of very fragmentary data from the section MN–1/89 and MN–2/89.

Pollen sequence noted in the section MN–3/89 proves a great similarity to a vegetation sequence of Biała Podlaska type, represented in numerous section. It allows to consider a vegetation sequence from the section Mokrany Nowe MN–3/89 to be synchronic with the one of Biała Podlaska one in its pre-interglacial part and from the ealier part of the interglacial. Presence of a microsporangium of *Azolla filiculoides* and of sediments with abundant pollen of *Abies* and *Carpinus* (but without spruce) enables to draw a similar conclusion on age of the sediments. If referred to other floristic sequence of similar climatic meaning, the flora from the section MN–3/89 indicates much more differences than similarities. No sediments with abundant *Taxus, Abies* with *Carpinus* and *Quercus* were noted. This fact seems to be due a lack of sediments from a younger part of the interglacial. Upper part of preserved organic sediments in analyzed sections is of erosive character.

A similar geologic-geomorphologic setting (absence of glacial series above) of organic sediments is known from an ancient axbow at Jammno Domaniewickie near Łowicz, the age of which is ascribed by Janczyk-Kopikowa (1989) to the Mazovian Interglacial.

There are two possibilites to explain such astonishing biostratigraphic conclusions. The first says that the analyzed series of organic sediments from Mokrany Nowe indicates residuum of destructed glacial sediments that has not been however noted in the hitherto boreholes or such sediments have been completely destructed. Geomorphologic setting of the site does not speak for such explanation but it still can be acceptable. The other possibility speaks for two or more similar interglacial floristic sequences that are ascribed to the Mazovian Interglacial. Existing doubts made the authors collect the next section of organic sediments from the borehole MN–4/90, although no complete core was received.

Mokrany Nowe MN–4/90

Organic sediments from this section supplied with 11 samples to palynologic investigations, each every 20 cm on the average. These sediments indicate distinct lithologic variation what suggest possible sedimentary hiatuses, presence of which is also supported by conclusions from palynologic investigations (Fig. 6). Results of palynologic investigations enabled to distinguish only two principal pollen horizons, separated by distinct sedimentary and stratigraphic hiatus.

Pollen horizon MN-4-A *Picea-Alnus* (samples 7–11, depth 2.6–3.6 m). Samples were collected at every 20 cm. They indicate a lithologic variation in the top part of the series. Underlying bituminous shales are crashed and mixed, together with sand or amids sands. Pollen spectra are predominated by *Picea* (16–33%) and *Alnus* (28–34%), with decidedly smaller quantities of *Fraxinus* (2–5%), *Quercus* (2–3%), *Tilia cordata* type (2–3%), *Ulmus* (1–2%). *Taxus* (about 5%) and *Corylus* (about 3%) are distinctly more abundant in the upper part of the horizon. Pollen of other trees are not important (*Pinus, Larix, Betula*). Upper limit of the horizon is very sharp and distinct, indicated by a drop of curves of *Alnus* and especially of *Picea*, and by abundant presence of *Carpinus* and *Abies*, and rise of *Quercus* and *Corylus*. appeared *Pterocarya*.

Contents of NAP in sediments of this pollen horizon are very small (2.5%), with *Hedera, Viscum, Ilex* and *Vitis, Humulus, Viburnum* and *Frangula alnus* are almost constantly present. Samples 11–8 contain abundant colonies of *Pediastrum* (43–125%), indicating stagnant waters in this reservoir or their limited flow and good insolation. Lower part of the horizon contains numerous pollen of *Myriophyllum spicatum, Typha latifolia, Sparganium* type, occasionally *Nuphar* and microsporangia of *Azolla filiculoides*. There are numerous of *Polypodiaceae* and rare *Osmunda, Sphagnum* and *Lycopodium clavatum.*

Such pollen spectra of the pollen horizon MN-4-A *Picea-Alnus* prove dense forests, with spruce on moist habitats and with alder in wet or flooded zones. Only dry habitats or peatbogs could be sporadicly overgrown by pine and birch. Presencs of ash, elm, oak, linden and in the upper part of the horizon of hazel should be connected mainly with drier forests. Occasional larch occured mainly in communities predominated by spruce. Presence of yew should be connected with wet habitats i.e. with spruce or alder.

Pollen horizon MN-4-B *Abies-Carpinus* (*Quercus-Corylus*), samples 1–6, depth 1.5–2.6 m, indicates abundant pollen of *Abies* (20–30%) and *Carpinus* (10–15%), and significant particularly in the bottom content of *Quercus* (5–8%), *Corylus* (4–7%) and *Alnus* (10–16%). There are constant although small quantities of *Pinus* (20–37%), *Picea* (about 1%), *Betula* (3–4%), *Tilia, Ulmus, Pterocarya* (about 0.5%). Only in single samples and minimum values there are *Fraxinus, Celtis, Larix, Acer* and *Salix*. Pollen of herbs and bushes is rare (4–7%). There is constant presence of *Buxus, Vitis* and *Vaccinium*, occasionally of *Frangula alnus* and *Stellaria holostea*. High values are reached by *Salvinia* and *Sphagnum* (2–4%). Pollen in sediments of this horizon are relatively considerably destroyed, greatest in the whole section. No algae have been practically noted. The uppermost sample of this horizon indicates a slight rise of *Pinus* and *Picea*, and a small drop of *Abies* and to a smaller degree – of *Carpinus*. It may point out a final part of this pollen horizon.

No distinct quantitative variation is noted between six samples of this pollen horizon. The same is also true for taxon contents that could reflect evolution and transformation of existing forest communities, known from other analyses of flora of the Mazovian Interglacial of the Biała Podlaska type (Krupiński 1984–85, 1988a, Krupiński et al. 1986, 1988, Krupiński & Lindner 1990). It suggest that sediments from this pollen horizon in the section MN-4/90 come from a similar floristic phase or result from their

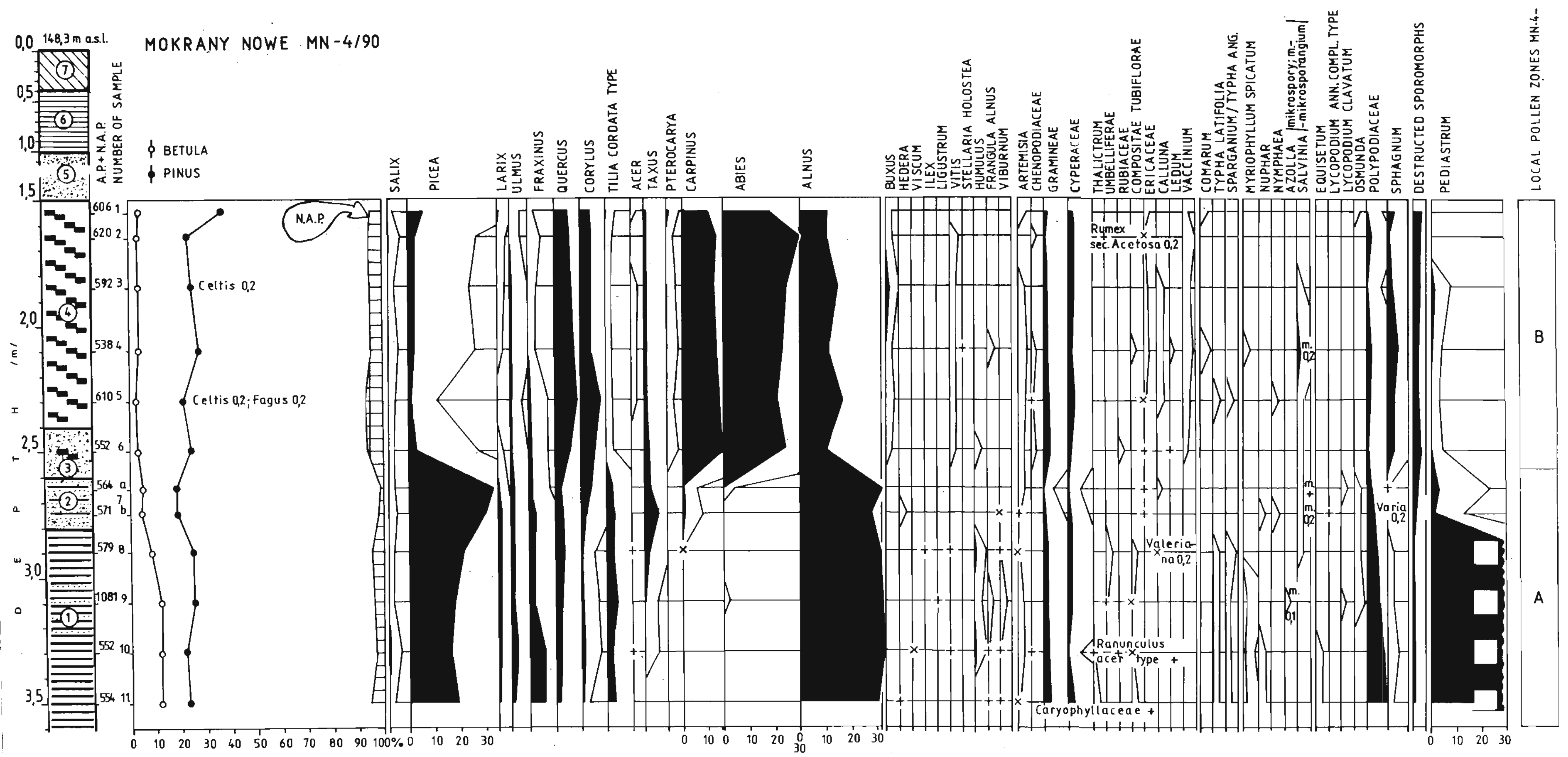

Fig. 6. Mokrany Nowe MN–4/90, pollen diagram. 1 – bituminous shales, partly with sand, 2 – vari-grained sand with gravel and crashed pieces of bituminous shales, 3 – vari-grained sands with gravel and organic matter, 4 – peat, 5 – sand with gravel, 6 – clay, 7 – soil horizon A_1. Local pollen zones: A – *Picea-Alnus*; B – *Abies-Carpinus-(Quercus-Corylus)*

destruction and then deposition within the same reservoir or depression. The flora seems to come from the same interval. Sediments in the lower part of the pollen horizon i.e. sands with peaty organic matter, then distinctly decomposed and sandy peats support such interpretation.

Upper border of preserved organic sediments and of the overlying sands in the section MN–4/90 is very sharp, probably of erosive character. Considerable part of the sediments could have been destroyed what makes a flora from the younger part of this interglacial be absent in this section.

Results of palynologic investigation from the pollen horizon MN–4–B *Abies-Carpinus* (*Quercus-Corylus*) enable to connect its origin with predominating in this area dense mixed fir-hornbeam forests with abundant oak, at first also with numerous hazel. Rare there are linden, yew, ash, elm, walnut, spruce (quite abundant in the younger part). Rare persisting alder swamps and peatbogs were occupied mainly by alder, accompanied by spruce, willow, birch, elm or even pine. Finally, dry habitats could be overgrown by pine forests.

This pollen horizon corresponds with the main development phase of box and grapevine. It idicates a mild, warm and moist climate with distinct marine features i.e. temperate warm and long vegetation periods, and relatively mild and short moist winters what favored development of peatbogs and of plants sensitive to long and frosty winters, and hot, dry vegetation seasons.

The paleoflora from the section MN–4/90 is undoubtedly of interglacial character. Climatic conditions deposition of the pollen horizon MN–B *Abies-Carpinus* (*Quercus-Corylus*) vere more favorable than during the climatic optimum of the Holocene. Floristic composition and vegetation sequence indicate most similarities to the ones from the Mazovian Interglacial of the Krępiec type (cf. Janczyk-Kopikowa 1981), from Biała Podlaska (Krupiński 1984–85, 1988a, Krupiński et al. 1986, 1988) or Komarno (Krupiński & Lindner 1988, 1990). But the similarities there are also distinct differences in vegetation sequence.

No sediments from the first part of the interglacial are preserved in the section MN–4/90. They were noted however in the neighboring section MN–3/89 where deposition started already during the late glacial period. The section MN–4/90 does not contain a record with communities with abundant yew what can be due to rare sampling. Detailed analysis of paleoflora of Biała Podlaska, Krępiec or Komarno type (Krupiński 1984–85, 1988a, Krupiński et al. 1986, 1988) indicate that about 20–25% of yew should be expected. This phase lasted however for a relatively short time. High values of yew are generally noted in a single sample and therefore too rare sampling could omit the main phase of yew. Entrance of yew in this section is similar as in other sections of previously presented sites.

Appearance of the first pollen of yew in the section MN–4/90 is connected with distinct destruction and deformation of the sediments. Bituminous shales are crashed with sand in between.

In the interglacial sequence of the Biała Podlaska, Komarno and Krępiec types the main phase of yew and the hornbeam-fir or fir-hornbeam phases are separated by transitional increase of *Pinus* pollen what can be sometimes bipartite (Krupiński 1984–85, 1988a). Its absence in the section MN–4/90 should be connected with existence of a distinct hiatus in this part, supported by considerable lithologic variation, type of sediments and curves of *Carpinus* and *Abies*, particularly of the former one. In this part of the section MN–4/90 there is sand with bituminous shales and sand with peaty organic matter. Generally these sediments are deposited in various sedimentary environments. *Carpinus* appears relatively early and its curve rises very gently. In the section MN–4/90 the *Carpinus* curve rises rapidly (see Fig. 6) what can be due to a rare sampling.

The last feature that makes this diagram fragment different from the compared ones from Biała Podlaska (Krupiński 1984–85, Krupiński et al. 1986, 1988) and Komarno (Krupiński in prep., Krupiński & Lindner 1988, 1990) is absence of distinct variation of *Abies* and *Carpinus* pollen and no interglacial maximum of *Quercus* pollen is noted. In Biała Podlaska it occurs the end of maximum values of *Carpinus* and before the last interglacial maximum of *Abies*. It occurs within the pollen horizon BP–H *Carpinus-Quercus-Corylus-Abies* (*Alnus*) and forms a separate subhorizon H–2 (Krupiński 1988a). Raise of *Corylus* pollen at the beginning of the hornbeam-fir phase in this section is relatively weak (see Krupiński 1988a – pollen horizon BP–G *Carpinus-Abies-Quercus-Corylus* (*Pinus-Alnus*)).

Such variation of pollen spectra from sediments of the section MN–4/90 if compared with the ones from the neighboring Biała Podlaska and Komarno, is presumably due to physiographic factors. Depression at Mokrany Nowe was in spite of small dimentions, occupied by a water reservoir. Small size made all slope processes or in the neighborhood be expressed in bottom sediments of the reservoir. Hiatuses could occur and the sediments themselves were very exposed and sensitive to destruction. Small area and insignificant hypsometric variation around the reservoir made the bottom sediments receive no cover during disappearance of interglacial or postinterglacial vegetation. Bottom sediments were considerably exposed to destruction, particularly during younger glacial advance and by processes of a periglacial zone.

The mentioned arguments explain why derivation of the paleoflora is, in spite of existing differences and hiatuses in vegetation sequences, connected by this author with the Mazovian Interglacial of Krępiec-like sequences i.e. of Biała Podlaska type (see Krupiński 1988a).

OUTLINE OF PALEOGEOGRAPHY

Presented organic sediments at Mokrany Nowe are separated from the underlying till by clayey sand with gravel (Fig. 2, layer 2), clay (layer 3), flow till (layer 4) and clay (layer 5). These layers are considerably inclined and parallel to the depression bottom (Fig. 2, section C–D) what indicates postsedimentary deformations. Hiatus within clays (layer 3 and 5) can be connected with lowering of the reservoir bottom what enabled inflow of till from its slopes. All these observations and types of sediments indicate univocally melting out of buried glacial ice blocks.

Deposition of bituminous shales in section MN–4/90 (Fig. 6) is connected with interglacial climatic optimum. It has been interrupted by erosion, resulting in cutting the shales to a depth of 1 m. This process is to be connected with sudden outflow of water from the reservoir. Erosive depressions (Fig. 2) are filled with varigrained sands with gravel and crashed fragments of redeposited shales and organic matter (layer 8). Pollen spectrum of these shales indicates their interglacial derivation (section MN–4/90 and samples from MN–1/89 and MN–2/89; Figs 3, 4 and 6). Breaks in deposition were accompanied by flows of sandy-gravel material (Fig. 2, layer 9) on sediments that fill erosive cuttings.

After erosion and deposition a renewed organic accumulation occurs. It starts with silts (Fig. 2, section A–B, layer 10) without pollen. Overlying peats (Fig. 2 section A–B, layer 11) contain pollen of interglacial derivation (section MN–3/89, MN–4/89; Figs 5, 6). Fragments of preserved floristic sequence (Fig. 5) should be connected with preliminary part of the interglacial of the Biała Podlaska, Krępiec or Komarno types (Krupiński 1984–85, 1988a, Krupiński et al. 1986, 1988).

Absence of till of the Odra Glaciation and presumably also of the Warta Glaciation, on organic sediments of the Mazovian Interglacial at Mokrany Nowe, accompanied by a small thickness of these tills in the neighboring area and by location of the site at outlets of two large erosive channels (Fig. 1) connected with valleys of Bug and Krzna rivers, can be only explained by their erosive destruction. Overlying sands, gravels and clayey sands (Fig. 2, layers 12–14) are due to glaciofluvial deposition of the Odra (?) or Warta (?) Glaciation. The youngers erosive incisions (Fig. 2) come from the warm – interglacial (?) period. They are filled by sands, clays, sands with gravels (layer 15–17), probably from a cool period.

CONCLUSIONS

Results of geologic, geomorphologic and palynologic studies make the author (Nitychoruk) draw the following conclusions.

Deposition of organic sediments in the site Mokrany Nowe occured in two phases. The first one is represented by bituminous shales. Their palynologic studies enable to connect them with interglacial optimum of the Biała Podlaska, Krępiec and Komarno type. During the second phase silts and peats were deposited (they are underlain by shales). Plant remains of peats allow to connect their origin with the beginning of the interglacial of Biała Podlaska, Krępiec and Komarno sequence. These sediments, typical for the successive phases, are separated by a sedimentary hiatus during which the shales were eroded and then sands with gravels and pieces of shales were deposited in the incision.

A situation when organic sediments from the beginning of the interglacial (peats) overlie the sediments from the optimum of the same interglacial (shales) can be considered for the effect of complex glaciotectonik deformations (however not confirmed until the present) or for the evidence of two warmings of interglacial type. This last conclusion is supported by studies of Lindner, Grzybowski (1982), Wojtanowicz (1983), Rzechowski (1986), Lindner (1988) and Lindner et al. (1988).

Geologic-paleobotanic studies of organic sediments from this site have not been finished yet and are to be continued. Within the subject "Conditions of deposition of interglacial organic sediments at Mokrany Nowe in Podlasie", partly financially supported by the Warsaw University, field and laboratory analyses could be considerably enlarged. New section of organic sediments (MN–5/90) was collected with the use of Więckowski's auger and mineral samples were taken for thermoluminescence analyses. It was the first section from this site, a full core of which was collected. These samples are at present analyzed and will be published later.

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