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Preliminary stratigraphy of organic sediments at Narew, northern Podlasie, eastern Poland

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Pollen analysis was conducted for sediments from two organic series in the profile Narew-III. Age of the lower series (depth 72.0–80.5 m) was determined as an upper part of the Lower Miocene. The upper is the Quaternary series (depth 58.5–61.55 m) which represents two warm climatic oscillations, separated by a cool period of a stadial rank. The older warmer period probably corresponds to an interstadial. The stratigraphic rank of the younger warmer period could not be determined on the basis of a palynologic examination as the pollen record includes only the very end of a warming and a beginning of the following cooling.

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Key words: Podlasie Region, Pleistocene, Miocene, pollen analysis.

INTRODUCTION

The northern Podlasie still belongs to the less recognized areas with respect to geologic structure and geomorphology. However, understanding of this area is critical to identification of stratigraphy and palaeogeography of the Middle Polish Glaciations, because glacial deposits of the Vistulian Glaciation do not occur in this area.

Two drill holes, aimed at determination of stratigraphy and thickness of the Quaternary sediments, were made during mapping of the *Detailed Geological Map of Poland* 1:50 000, the sheet Narew. The drilling Narew-III, located in the Narew River valley near the town of Narew (Fig. 1), was drilled, among other goals, in order to determine the age of two organic series, which where known from the archival drill logs (W. Kwiatkowski *et al.*, 1995). This drill hole reached depth of 115 m and confirmed the presence of two series rich in organic material (Fig. 2):

— ice-dam lake silts, clayey silts and silty sands at a depth of 58.5–61.55 m, below two tills;

— fine- and medium-grained sands at a depth of 72.0–80.5 m, from a depth of 84.6 m pass downwards into the Oligocene green-grey and greenish sands.

A pollen analysis was done for 62 samples, including 40 from the lower series and 22 from the upper one.

POLLEN ANALYSIS

All samples were prepared using the same method. After boiling a sediment with 5% KOH, the mineral fraction was separated from the organic one by application of aqueous solution of potassium and cadmium iodides of the unit weight of 2.1 g/cm^3. Then, the material was subjected to acetolysis (G. Erdtman, 1943).

Results of the pollen analysis of the upper series are presented in a percentage pollen diagram (Fig. 3). Percentage values of specific taxa were calculated in relation to the total which includes pollen of trees, shrub and bushes (AP), and

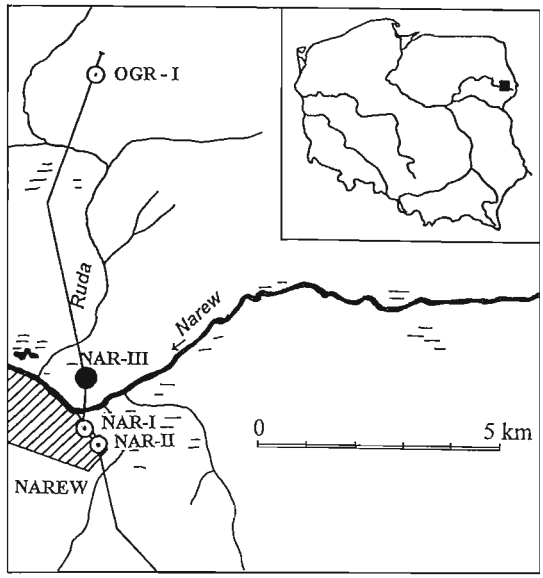


Fig. 1. Location of the study area

NAR-I and NAR-II — drillings before 1996; research drillings: NAR-III — Narew-III, OGR-I — Ogrodniki-I

herbaceous plants (NAP), with exception of aquatic and rush plants. Contribution of excluded taxa from the total and of cryptogamic plants, algae, and sporomorphs indeterminate, was calculated from a total, increased by a number of sporomorphs of a specific group. In the pollen diagram, local pollen assemblage zones were determined (Z. Janczyk-Kopikowa, 1987), names and symbols of which start with numbering from a bottom of the profile.

LOWER SERIES

Sediment lithology from a depth of 72.0–80.5 m in the profile Narew-III is as follows:

Depth in m	Lithology
72.00–72.40	Brown fine-grained sands with gravel of 1 cm diameter, at the top 72.00–72.03 m interlayer of brown organic remains.
72.40–72.45	Silt and brown vari-grained sands.
72.45–73.00	Coaly fine-grained sands.
73.00–76.70	No core obtained.
73.70–76.80	Coaly fine-grained sands, locally compressed, at a depth of 74.20–75.30 m interlayers of brown coal.
76.80–78.20	Very fine-grained coaly sands.
78.20–79.30	Very fine-grained sands with clear interlayers (0.5–1 cm) of brown coal.
79.30–80.00	Brown coal.
80.00–80.20	Very fine-grained sands, silty, grey-beige with dominance of brown coal.
80.20–80.50	Very fine-grained sands, gray, with interlayers of brown coal (thickness about 0.5 cm).

40 samples from this core fragment were subjected to pollen analysis. In samples from a depth of 72.00–75.75 m (17 samples) and 79.30–80.50 m (4 samples) neither pollen nor spores were detected. However, frequency of sporomorphs in 19 samples from a depth of 79.25–75.80 m with some exceptions is high or very high, and their preservation quality is very good.

Pollen spectra are characterized by a significant richness of pollen taxa. Their composition indicates that broad marshy areas, covered with wetland forest with *Alnus, Nyssa, Liquidambar*, numerous representatives of Taxodiaceae-Cupressaceae, shrubs as *Ilex,* Ericaceae, Cyrillaceae-Clethraceae, Caprifoliaceae, Myricaceae, ferns and peat moss, have predominated in the region. Marshy forest could have occurred along rivers with *Ulmus, Pterocarya, Fraxinus* and *Salix.* Trees like *Pinus, Picea, Abies, Tsuga, Sequoia, Sciadopitys, Betula, Tilia, Carpinus*, and *Quercus* probably occupied drier areas and possibly encroached on wetlands during their drying. Some trees of these types could contribute an admixture to wetland assemblages. Plants of dryphilous open assemblages are poorly represented by individual pollen grains of *Artemisia* and Chenopodiaceae.

The organic series was classified as the Quaternary during sampling. Results of palynologic examination lead to a modification of this concept. Vegetation picture obtained from the pollen analysis allowed to refer it explicitly to the Tertiary and to determine its age as an upper part of the Lower Miocene. Exceptional quality of the pollen material qualifies the considered sediments to a detailed study of a palynologist specialized in the Tertiary.

UPPER SERIES

In this series (depth 58.5–61.55 m) 5 local pollen assemblage zones (L PAZ) were distinguished.

The **zone N-1** — *Corylus-Pinus-Alnus* (depth 60.95–61.45 m) with low or very low pollen frequency. AP content is about 80%. *Pinus* is the predominant tree (40–53%). *Corylus* reaches relatively high values, up to 10%. *Betula* decreases from 12 to 8%. *Alnus* content ranges from 8 to 10%. Dinoflagellate, and the Tertiary pollen and spores occur regularly. There is a high content of damaged and corroded pollen.

The zones N-1 and N-2 are separated by the barren bed 1 without any sporomorphs.

The **zone N-2** — *Pinus-Alnus* is represented by a single pollen spectrum (depth 60.7 m). Pollen frequency is low. Trees, among which *Pinus* (65 %) and *Alnus (*9%) dominate, form 88% of the total. Content of *Betula* (8%) slightly decreased in comparison to the previous pollen zone. Herbaceous plants are mainly represented by *Artemisia* (6%). Content of damaged and corroded pollen is relatively high. Dinoflagellate, and the Tertiary pollen and spores occur regularly.

The zones N-2 and N-3 are separated by the barren bed 2 without any sporomorphs.

The **zone N-3** — *Betula-Artemisia*-Chenopodiaceae is represented by a single sample (depth 60.3 m). Pollen frequency is relatively high. Exceptionally high percentage values are reached by *Artemisia* (25%). Additionally, Gramineae (6%), Chenopodiaceae (4%), *Filipendula* (2.5%) and Caryophyllaceae undiff. (1.5%) have relatively high content among the herbaceous plants. The following pollen also occurs: *Gypsophila fastigiata, Helianthemum nummularium* type, *H.*

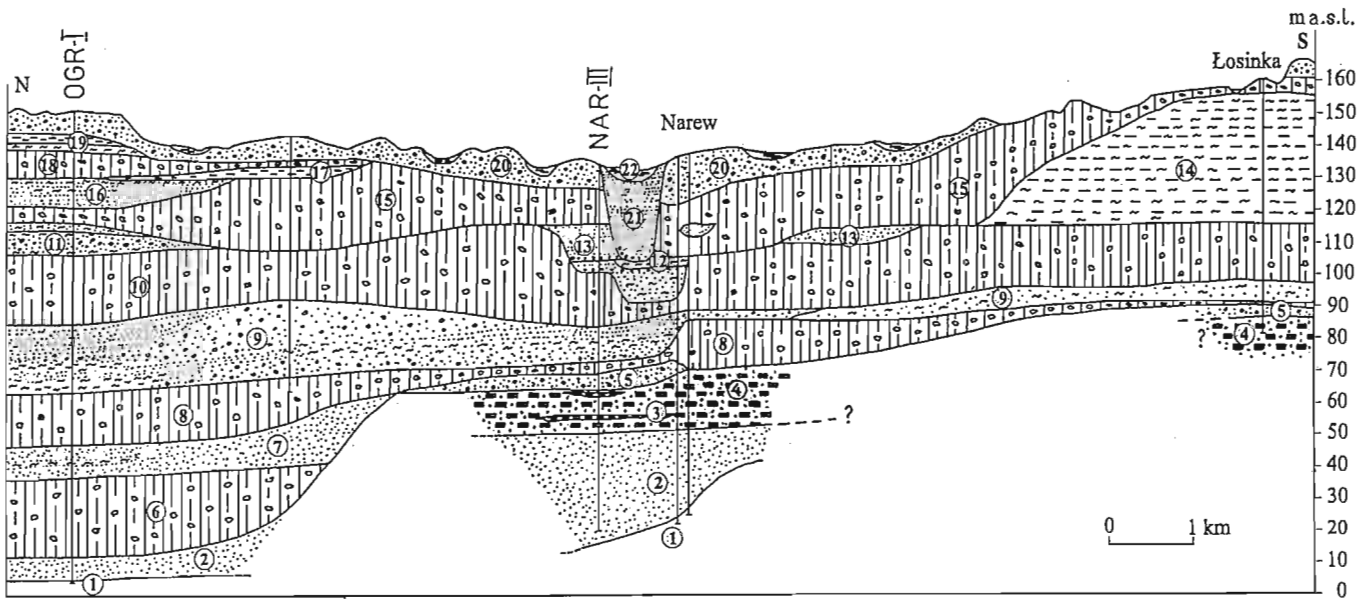


Fig. 2. Simplified geologic cross-section of the upper Narew River valley near the town Narew (detailed stratigraphy is not provided, because lithologic-petrographic analysis has not been completed yet)

Cretaceous: 1 — calcareous mud; **Oligocene**: 2 — glauconite sands; **Miocene**: 3 — brown coal, 4 — sands, clays, and coaly silts; **Pliocene(?)–Prepleistocene (?)**: 5 — fine- and medium-grained sands with gravel; **South Polish Glaciations**: 6 — lower till, 7 — fine-grained sands interlayered with silts, 8 — upper till; **Mazovian Interglacial(?)**: 9 — silty sands, silts and sands with gravel, layered; **Odranian Glaciation**: 10 — till, 11 — clayey silts and sands; **Lubavian (Lublinian, Pilica) Interglacial?**: 12 — river sands and silts; **Wartanian Glaciation**: 13 — sands and gravels, 14 — clays and silts of proglacial lakes, 15 — lower till, 16 — fine-grained and silty sands, 17 — clays, 18 — upper till, 19 — clays and silts, 20 — sands and gravels; **Vistulian–Holocene**: 21 — river sands and gravels; **Holocene**: 22 — peats and hydrogenic deposits

oelandicum type, Rosaceae, *Rumex acetosa/acetosella,* Rubiaceae and *Thalictrum.* Trees are mainly represented by *Betula* (15%). *Pinus* is represented by the lowest value in the profile (23%).

The zones N-3 and N-4 are separated by the barren bed 3 without any sporomorphs.

The **zone N-4** — *Pinus-Betula-Sphagnum* (depth 58.90–59.50) has a relatively high pollen frequency. Trees, mainly *Pinus* (64–79%) and *Betula* (4–18.5%) dominate with a small contribution of *Picea* (up to 3%) and *Alnus* (up to 1%). Herbaceous plant content gradually increases from 2.5% in the lower part of the zone to 13% in its upper part. Relative high percentage values represent *Sphagnum* (10–18%). Algae of *Pediastrum* (*P. kawraiskyi* dominates) are very abundant. The upper boundary of the zone was defined as significant decrease of percentages of *Pinus* to 37%, increase of contents of Cyperaceae and *Artemisia*, and appearance of Chenopodiaceae.

The **zone N-5** — NAP-*Betula nana-Salix* (depth 58.50–58.90) has a low pollen frequency and a very high content of NAP (40–52%). Cyperaceae (28.1 %), Gramineae (18.2 %), *Anemone* type (1.5%) and *Gypsophila fastigiata* (1.2%) reach maximum in the profile among the herbaceous plants, whereas *Betula nana* type (8%) — the highest values among shrubs and *Salix* (2.6%) among trees. Culmination of *Artemisia* (13.6%) occurs. *Juniperus* increases to 1%. Pollen grains of Chenopodiaceae, *Helianthemum nummularium* type, *Filipendula, Thalictrum, Aster* and *Anthemis* types occur regularly. Among trees, mainly *Betula* (up to 15%) and *Pinus*, which reaches its absolute minimum (17%), are determined. *Pediastrum*, mainly *P. kawraiskyi* have very high values.

VEGETATION

The zone N-1 — *Corylus-Pinus-Alnus*. A picture of vegetation recorded in pollen spectra indicates the presence of a moderately dense pine-birch forest. Hazel was probably the brushwood of these forests in the most fertile habitats, and small admixture is contributed by spruce and stenothermal deciduous trees such as lime, hornbeam and elm. Relatively high content of NAP suggests occurrence of broad areas with open vegetation. Assemblages with juniper, *Ephedra*, sea buckthorn, motherwort, Chenopodiaceae and rock-rose occupied dry sandy habitats. More wet localities were dominated by high herbal shrubs with *Filipendula*, meadow rue, valerian, representatives of Umbelliferae and shrubs of willow and birch.

A sedimentary basin formed a lake, with algae of *Pediastrum* and *Botryococcus*. Hydrophilous assemblages with ferns and peatmoss were present in the vicinity.

The zone N-2 — *Pinus-Alnus*. Drop in a content of hazel in a pollen spectrum and lack of lime, hornbeam, and oak indicate a retreat of trees with higher thermic requirements. Areas occupied before by assemblages with these trees became dominated by a pine forest. An area of wet alder forest has

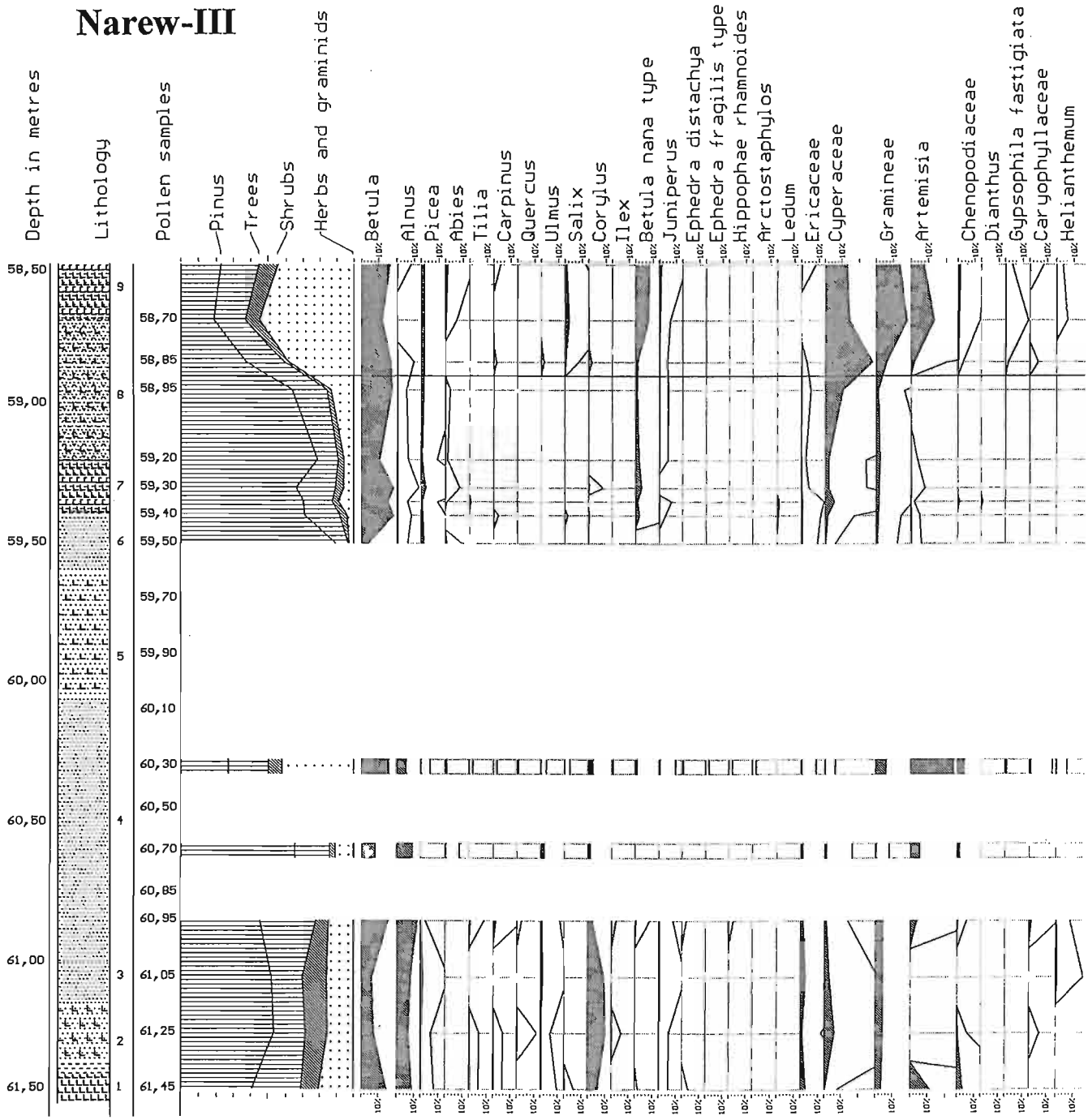
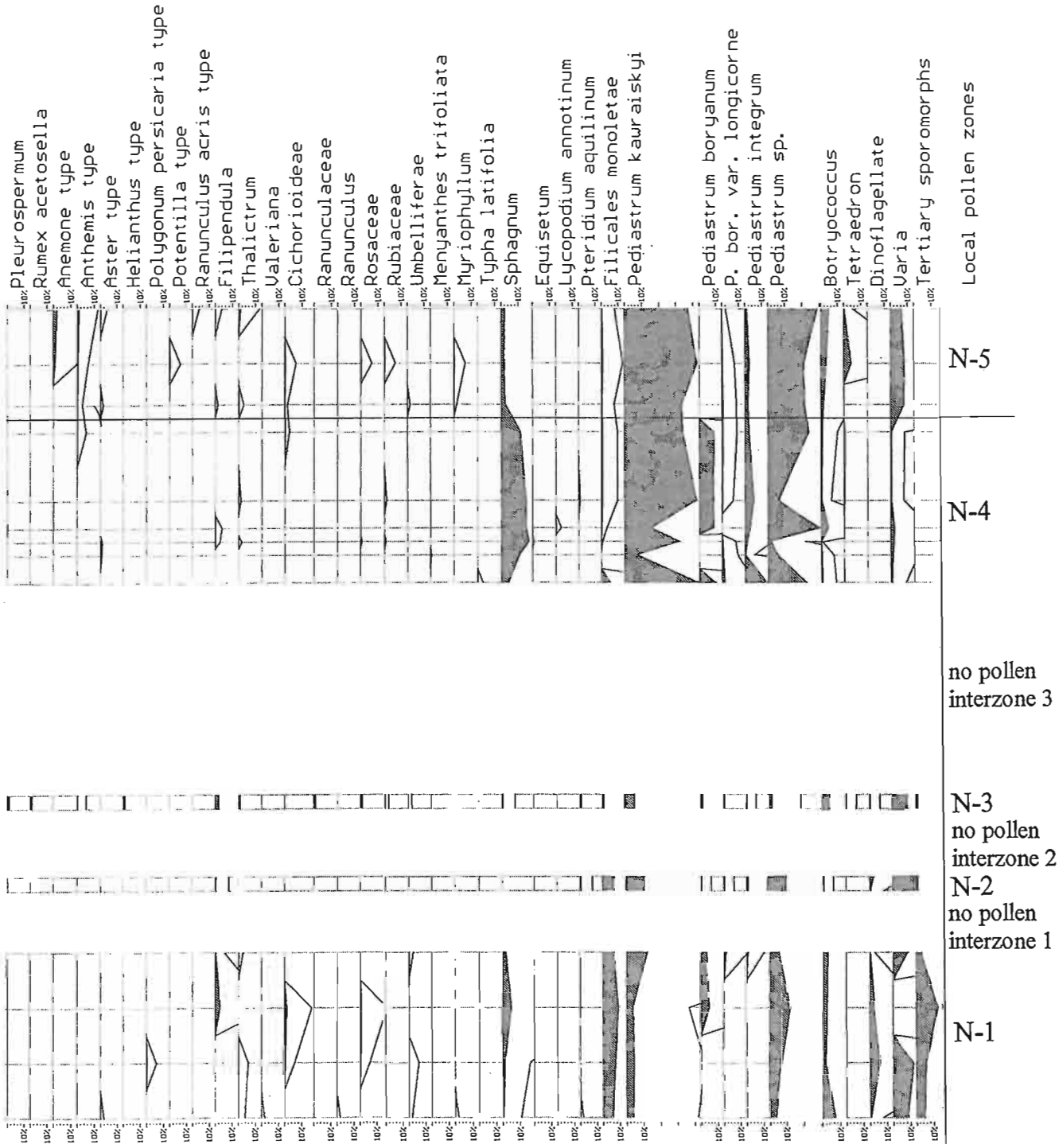


Fig. 3. Narew-III: percentage pollen diagram of the upper organic series
Lithology (simplified graphical symbols according to J. Troels-Smith, 1955): 1 — dark grey silt, 2 — fine- and medium-grained sands with dominance of silts, at a depth of 61.4 m a layer 0.5 cm of dark organic material, 3 — grey vari-grained sands with dominance of medium-grained, 4 — grey-green very fine-grained

not decreased in comparison to the previous period. Open assemblages with motherwort and Chenopodiaceae somewhat expanded in dry sandy habitats. The lake has not changed its characteristics.

The zone N-3 — *Betula-Artemisia*-Chenopodiaceae. Open assemblages preferring dry conditions, of a cold steppe type, mostly consisting of motherwort and Chenopodiaceae accompanied by Caryophyllaceae, *Gipsophila fastigiata*, rock-rose, some grasses and shrubs such as juniper, sea buckthorn and *Ephedra*. Their expansion proves predominance of cold, but dry climate. A forested area became significantly reduced. Assemblages with pine and birch were still prevailing among them. Relative proportions between these trees, however, changed: importance of pine significantly decreased



sands, 5 — grey-green very fine-grained sands with dominance of sandy silt, 6 — grey very fine-grained sands, 7 — dark brown silts with interlayers of black organic material, 8 — black silty sands with organic material, 9 — dark brown clayey silt with black organic material

and content of birch increased. Alder forests covered areas somewhat smaller than in the previous periods; possibly it resulted from dryness of climate which caused lowering of a ground water level. The lake did not changed its character at that time.

The zone N-4 — *Pinus-Betula-Sphagnum*. Pollen spectra document a predominance of a pine forest with relatively large content of birch and small admixture of spruce. High values of *Pinus* prove the dominance of this tree in most habitats. A small amount of *Alnus* indicates a very limited extent of wet alder forests. A relatively small area was occupied by the open vegetation. Assemblages with majority of grasses and sedges dominated, possibly accompanied in wet localities by shrub birches and willows, *Filipendula* and me-

adow rue, in dry areas dominated by motherwort, Chenopodiaceae and individually growing junipers.

The accumulation basin was then without outflow. Percentage increase of algae of *Pediastrum* may indicate lowering of a lake water level (*cf.* S. Tołpa, 1961). A large content of *Pediastrum kawraiskyi*, accompanied by *P. integrum* indicates cool waters, from oligotrophic to dystrophic. Large amount of *Sphagnum* spores may suggest occurrence of peat pla around margins of the lake.

The zone N-5 — NAP-*Betula nana-Salix*. Above 50% of herbaceous plants in pollen spectra indicate huge expansion of the open vegetation. Tundra assemblages dominated with majority of grasses and sedges, shrub birch and willow. Large areas were occupied by high herbal shrubs in topographic depressions with *Filipendula* and *Thalictrum*. Heliophites with *Artemisia,* Chenopodiaceae, *Gypsophila fastigiata, Helianthemum nummularium* type and *Juniperus* developed in the dry sandy habitats.

Continuous presence of *Pediastrum kawraiskyi* and *P. integrum* in pollen spectra suggests that the lake most probably has not changed in any significant way. A significant decrease of *Sphagnum* spores with simultaneous increase of *Filicales monoletae* may reflect changing assemblages at margins of the lake.

AGE

Based on the palynologic examination, the analyzed part of the profile Narew-III should be related undoubtedly to the Pleistocene. Based exclusively on a pollen analysis, a more precise age assessment is not possible.

Palynologic record in the pollen spectra from a depth of 60.95–61.45 m (zone N-1) probably indicated a climatic optimum of a warmer interstadial-like oscillation. The pollen zone N-2 represents probably a final phase of this interstadial, and the zone N-3 — the following stadial cooling. Unfortunately, interstadial plant successions do not have specific features, which would allow to determine their age.

A vegetation picture reconstructed on the basis of the pollen spectra from a depth of 58.5–59.5 m indicates that it represents a final part of a warm climatic oscillation (zone N-4) and the following, the first climatic cooling (zone N-5). Vegetation character does not allow, however, to determine the rank of this warming — it may be either the end of an interstadial or the end of an interglacial. The picture of vegetation in the final stages of warm periods of so different ranks developed in a very similar way and thus, it cannot be used as a diagnostic feature to determine their age.

DISCUSSION AND CONCLUSIONS

A revision of concepts associated with geologic structure of the study area (W. Kwiatkowski *et al.*, 1995) was based on the mapping drillings along the geologic cross-section of the Narew River valley in the western part of the Białowieża Forest. Pollen analysis of the organic series, occurring beneath the Narew River valley at 54–62 m a.s.l., became the basis for this revision. These sediments used to be interpreted, based on the archival drill hole profiles as interglacial deposits within the South Polish Glaciations (Elsterian). Results of a palynologic study of these sediments from the drill hole Narew-III explicitly classify this series as the Tertiary deposits and allow to ascribe them to the Miocene sands, silts and coaly clays with interlayers of brown coal. This situation allows to consider — through analogy — green silts with a large content of organic remains, occurring in the Łosinka drill hole profile as the Miocene series, and to combine the underlying sediments with the Oligocene glauconite sands, also present in the profile Narew-III.

Based on the reinterpretation proposed in the area of the Narew River valley and to the south of it, top of the Tertiary deposits occurs at 63–68 m a.s.l., i.e. about 45–50 m shallower than it used to be assumed originally. The Pleistocene sediments are in this area reduced. The top of the Tertiary subsides north from the Narew River and occurs at 8.4 m a.s.l. in the drill hole profile Ogrodniki, and is directly underlied by the Cretaceous calcareous muds.

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WSTĘPNE ROZPOZNANIE STRATYGRAFII OSADÓW BIOGENICZNYCH W PROFILU NAREW NA PÓŁNOCNYM PODLASIU

Streszczenie

W trakcie prac kartograficznych w ramach *Szczegółowej mapy geologicznej Polski* 1:50 000, prowadzonych na arkuszu Narew, wykonano otwór wiertniczy Narew-III, położony w dolinie Narwi w pobliżu miejscowości Narew (fig. 1). Miało ono na celu określenie wieku dwóch serii organogenicznych, stwierdzonych w tym rejonie w wierceniach archiwalnych. Otwór ten osiągnął głębokość 115 m i potwierdził obecność dwóch poziomów bogatych w materiał organiczny (fig. 2).

Czterdzieści próbek z dolnej serii organicznej i dwadzieścia dwie próbki z górnej poddano analizie pyłkowej (fig. 3). Spektra pyłkowe z dolnej serii organicznej wskazują na dominację zbiorowisk leśnych reprezentowanych przez lasy bagienne z przewagą *Alnus, Nyssa, Liquidambar* i licznymi przedstawicielami Taxodiaceae-Cupressaceae, lasy łęgowe z *Ulmus, Pterocarya* i *Fraxinus* oraz lasy mieszane z *Pinus, Picea, Sciadopitys, Tsuga, Sequoia, Betula, Abies, Carpinus* i *Quercus*. Na podstawie analizy pyłkowej wiek osadów omawianej serii określono na wyższą część dolnego miocenu.

Zapis palinologiczny zawarty w spektrach pyłkowych z głębokości 60,95–61,45 m (poziom N-1 — lasy z dominacją *Pinus* i *Betula* oraz stosunkowo dużym udziałem *Corylus*) wskazuje, że sedymentacja tych osadów odbywała się podczas interstadiału. Poziom pyłkowy N-2 (lasy sosnowe i sosnowo-brzozowe) odpowiada prawdopodobnie końcowej fazie tego interstadiału, a poziom N-3 (roślinność otwarta o charakterze zimnego stepu z bardzo wysokim udziałem *Artemisia*) rejestruje następujące po nim ochłodzenie rangi stadiału.

Obraz roślinności zrekonstruowany na podstawie zapisu pyłkowego z odcinka 58,4–59,5 m młodszej serii organicznej wskazuje, że reprezentuje on schyłek ocieplenia o nieznanej randze stratygraficznej (poziom N-4: lasy z dominacją *Pinus* i *Betula* oraz niewielkim udziałem *Picea*) i pierwsze następujące po nim ochłodzenie klimatu (poziom N-5: roślinność otwarta z przewagą Gramineae, Cyperaceae, *Betula nana* typ, *Juniperus* i *Artemisia* oraz *Gypsophila fastigiata, Helianthemum*, Chenopodiaceae, *Filipendula, Thalictrum* i typami *Aster, Anthemis, Anemone*). Charakter roślinności nie pozwala na określenie wieku tego odcinka profilu za pomocą danych palinologicznych.

Wyniki analizy pyłkowej pozwoliły stwierdzić, że w rejonie doliny Narwi i na południe od niej strop osadów trzeciorzędowych znajduje się na wysokości około 63–68 m n.p.m., o około 45–50 m płycej niż zakładano to pierwotnie, a seria utworów plejstoceńskich jest zredukowana.