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Geology and palynology of Vistulian Glaciation deposits in closed basins near Jutrosin (southern Wielkopolska), Poland

Teresa KUSZELL and Jarosław WINNICKI

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Several closed, infilled basins dating from the last glaciation were found near Jutrosin in southern Wielkopolska. The Nadstawem is site located 1.5 km south-east from the centre of Jutrosin. The basins are located within end morainic hills which date back to the Wartanian Glaciation. The deposits comprise clay and sand with frost structures interbedded with till, overlain by sand and silt with three organic beds. Palynological studies have enabled reconstruction of the plant communities. Radiocarbon dating indicated about 38 700 BP for the lower organic bed without sporomorphs and *ca*. 29 000 BP for the upper two ones with a rich pollen spectrum. Hence, organic sedimentation ranged from the Hengelo Interstadial to the Denekamp Interstadial.

Teresa Kuszell, Institute of Geological Sciences, University of Wrocław, Cybulskiego 30, PL-50-205 Wrocław, Poland; Jarosław Winnicki, Department of Geological Cartography, Geological Enterprise "Proxima", Wierzbowa 15, PL-50-056 Wrocław, Poland *(received: November 9, 2000; accepted: November 15, 2001).*

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INTRODUCTION

A zone of closed basins filled with the deposits from the last glaciation occurs on the Kalisz Plateau, in the southern part of Wielkopolska (Fig. 1). In the vicinity of Jutrosin these basins lie in a zone of end moraines (Pachucki, 1956). Pachucki assumed that the forms dated from the recession of Wartanian ice; the sequence of the N–S end moraines most likely determines the maximum extent of the Wartanian Glaciation in this area (Winnicki, in preparation), with no evidence that this glaciation extended further south (Winnicki, 1997).

In this region of Wielkopolska organic deposits from the Vistulian Glaciation have been found in four places (Fig. 1). Their thickness reaches up to 10 m. They fill small closed depressions among morainic hills. Sediment was eroded from neighbouring hills mainly during cold periods. The sedimentation of organic strata took place in small and shallow lakes with impermeable floors during warm seasons (Fig. 1, sites A–C). Organic deposits are absent from, depressions with permeable floors (Fig. 1, site D).

LITHOLOGY

A complete profile of the basin deposits is exposed at the Nadstawem site, located on the southern wall of the closed gravel pit near Jutrosin at about 110 m a.s.l. (Fig.1). The Vistulian deposits are here underlain mainly by sands and gravels of the Wartanian end moraines, though in one borehole, located close to the centre of the basin about 20 m from the Nadstawem site, they were underlain by flow till. The Vistulian succession is bipartite and its lower boundary with the morainic deposits is distinct (Fig. 2).

The profile begins with light grey and greenish sandy clays and clayey sands. At the edges of the basin their thickness reaches 5 m. The deposits are slightly cohesive and fragment into small ball-shaped aggregates. There are rare gravels and individual crystalline rock cobbles with diameters of up to 25 cm, usually considerably weathered. In the northern part of the wall, fine-grained sand lenses with three thin strata of organic clayey silts were found. A small syngenetic frost wedge was associated with them (Fig. 2).

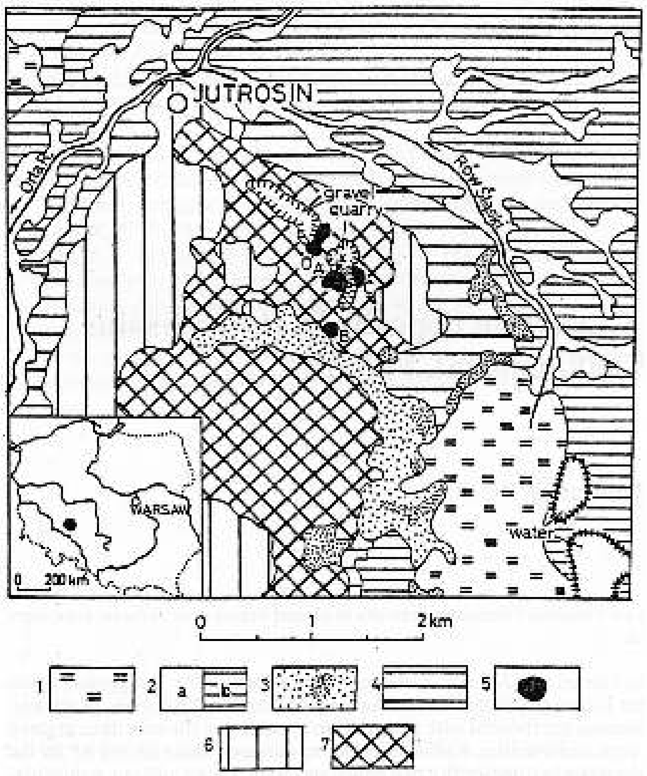

Fig. 1. Geological-geomorphological sketch of the Jutrosin area

Holocene: 1 — peat plains, 2 — sands with valley bottom gravels (a) and the lower terrace (b); **Vistulian Glaciation**: 3 — sand dunes and aeolian sand fields, 4 — sands with grains from the higher terrace, 5 — closed basins; **Wartanian Glaciation**: 6 — tills of the morainic flat upland, 7 — sands, gravels and clays of the end moraine; A–D — sites with the Vistulian deposits; x — location of the studied section (southern wall)

The grain size analysis of the deposits show that they are silty-clayey sands, where the content of the sand fraction slightly exceeded 50% (Dobosz and Skawińska-Dobosz, 1998), i.e. close to sandy clay. Their sorting is very poor (σ = 2.72) and is not different from values typical of flow tills. The deposits are characterised by a very low $CaCO_3$ content (up to 1.3%) in the < 0.1 mm fraction. The gravels mostly comprise Scandinavian crystalline rocks (64%), though no Palaeozoic limestones were found. Sandstones (5%) mostly represent northern rocks. In the local material, quartz (20%) and sandstone (4%) are the most frequent constituents. Grey siliceous hornstone clasts, probably derived from the Gozdnica deposits, are notably common. The transparent heavy minerals are dominated by garnet (41%). By comparison with other Quaternary deposits, the amphibole content (18%) is slightly reduced, minerals of the epidote group (9%), andalusite (7%) and zircon (6%) were also observed.

Very similar deposits were found in closed basins around Biesiekierz near Łódź in central Poland (e.g. Kamiński, 1992; Klatkowa, 1993, 1994).

The sandy and clayey deposits grade into a succession that includes three beds of peat and organic silts. The vertical profile consists of grey and beige, fine-grained sands, usually well-sorted, containing isolated fine gravel clasts, silty sands or, less frequently, sandy silt lenses. The deposits are usually finely laminated, sometimes slightly streaked and dipping to the SSW, towards the centre of the basin. They are often clayey and poorly sorted near the contact with the underlying deposits.

A few silty samples deposited between organic layers were analysed (Dobosz and Skawińska-Dobosz, 1998). Silty clays are the most frequent, with only one sample of clayey silt. The deposits are characterised by a very poor sorting approximating to values typical of flow tills. There are significant variations in the quantitative and qualitative composition of heavy minerals in the vertical profile. The transparent heavy minerals are characterised by a predominance of resistant components: garnet (up to 50%), andalusite (up to 15%), zircon and rutile in some of the samples. Quartz grains were poorly rounded (R = 1.08) in the 1–0.5 mm fraction. Partly rounded grains predominate, reaching 63%.

In the sandy and silty deposits, three organic layers were clearly recognised on the excavation wall (Fig. 2). Locally, usually at the edges of the basin, silts containing disseminated organic material or locally clayey peat, replace the peat. The average thickness of the two upper layers is between 20 and 30 cm. The lower layer (thickness rarely exceeding 5 cm) is in many places considerably compacted and divided into small irregular blocks. In the northern part of the wall, the organic deposits do not form continuous layers (Fig. 2). ^{14}C dates from the three peat layers were obtained in the Gliwice Laboratory (Pazdur, 1999). The age of the lower layer was determined at 38700^{+3650}_{-2000} (Gd — 12 122), the middle one at 29 000±1000 (Gd — 11 446), and the upper one at 28 500±950 (Gd — 11 450).

PALYNOLOGICAL ANALYSIS

The 2.70 m thick section from the Nadstawem site provided samples for palynological and ^{14}C analyses (Fig. 2). The pollen analysis was carried out on samples from the three organic beds and thin organic silt strata found in the lower clayey and sandy succession. No pollen was found in the lowest level and in the organic silts.

The following is a detailed description of the sediments from the Nadstawem profile:

Depth in metres	Lithology
0.00–0.20	Fine-grained and silty sands.
0.20–0.40	Peat, silty in some places.
0.40–1.30	Silty sands.
1.30–1.50	Peat.
1.50–1.70	Clayey silts, organic in some places.
1.70–2.40	Fine-grained sands and silts.
2.40–2.50	Peat and organic silts.
2.50–2.70	Silty sands.
below 2.70	Sandy clays.

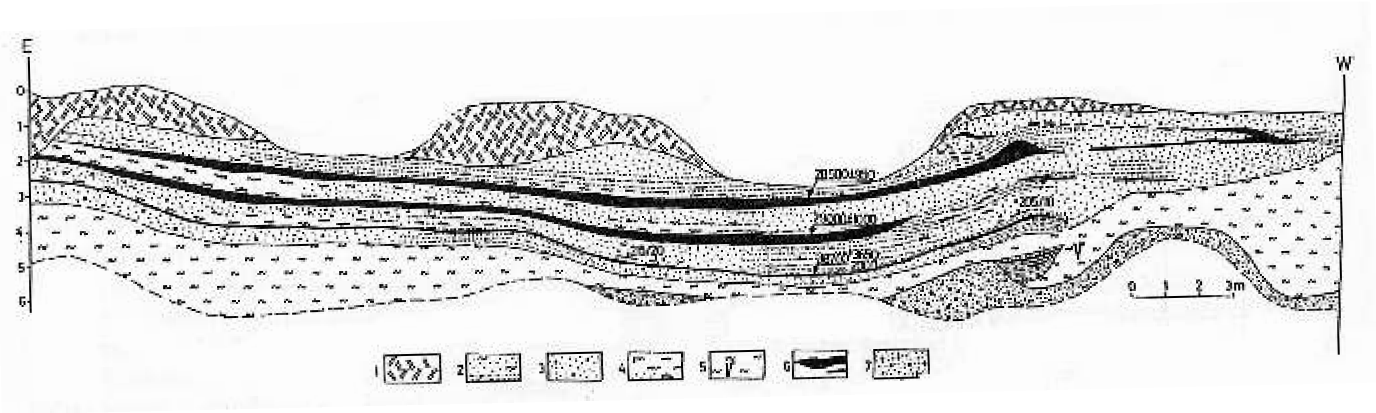

Fig. 2. The Nadstawem site — the southern wall profile

1 — talus, 2 — fine-grained sands, locally clayey, 3 — sands with gravel, 4 — silts, 5 — clays and clayey sands with a frost wedge, 6 — peat and organic silts, 7 — sands and gravels of the end moraine; 28 500±950 — radiocarbon dating

Biogenic deposits were macerated by boiling in 10% KOH and then Erdtman's acetolysis was applied. Before applying the acetolysis, the sand and silt samples were heated in hydrofluoric acid. The pollen spectra were counted on at least two slides and in the samples with a low sporomorph frequency it was recounted to five. The sporomorph frequency varied, from very high to a complete absence of pollen material. The results of the pollen analysis are presented in the diagram (Fig. 3), which contains only 13 pollen spectra from the depths of 0.20–0.50 m and 1.30–1.80 m. The percentages of particular taxa were calculated from the total sum (AP + NAP), containing trees and shrubs (AP) and herbaceous plants (NAP). The sum does not include helophytes or aquatic and spore-bearing plants (*Sphagnum* and Polypodiaceae). No admixture of Tertiary material reworked from the older deposits was observed. The diagram has been subdivided into 4 local pollen assemblage zones (L PAZ), which have been numbered from the bottom to the top of the profile and marked with the first letter of the site name.

LOCAL POLLEN ASSEMBLAGE ZONES

ZONE N1, SAMPLES 27–25 (DEPTH 1.80–1.60 M)

The pollen spectra are characterised by high values of herbaceous plant pollen (NAP), while trees and shrubs (AP) occur in much smaller quantities. Among the trees there is a considerable predominance of *Betula* and *Pinus*. In this zone herbaceous plants reach the highest values of up to 75%. *Artemisia* (28.3%) is the most numerous; Poaceae and Cyperaceae are less frequent. There is also pollen of Caryophyllaceae, Compositae, Cruciferae and Chenopodiaceae. Among the helophytes and aquatic plants only *Typha-Sparganium* has been determined.

ZONE N2, SAMPLES 24–20 (DEPTH 1.60–1.30 M)

In this zone the pollen of trees and shrubs is predominant. The *Pinus* curve increases to 60.1 %, while the values for *Betula* decrease from 48 to 13%. In the upper part of the zone *Picea* and *Larix* are more numerous. *Quercus*, *Corylus* and *Tilia* occur rarely. Herbaceous pollen values are reduced to a few percent and the variety of taxa considerably declines. The most significant regularly present are Ericaceae with a culmination of 3.2%. Polypodiaceae (26.7%) are more abundant. Similarly as in the previous zone, the pollen of *Typha-Sparganium* has been recorded for helophytes and aquatic plants.

ZONE N3, SAMPLES 12–10 (DEPTH 0.50–0.35 M)

In this part of the diagram herbaceous pollen is subordinate to that of trees and shrubs. *Pinus* and *Betula* are the most abundant. *Picea*, *Juniperus*, *Larix* and *Salix* occur only at low frequencies. The contribution of herbaceous plants, high at first, has decreased to 24%. Cyperaceae and Poaceae reach the highest values among the NAP. Caryophyllaceae, Chenopodiaceae, Compositae and *Artemisia* (the last contribution not exceeding 3.7%) are of lesser significance. The aquatic taxa have not been observed.

ZONE N4, SAMPLES 9–8 (DEPTH 0.35–0.20 M)

In the pollen spectra of this zone the percentage of tree and shrub pollen increases to 83.8%. *Betula* predominates, followed by *Pinus*. The contribution of *Picea* is low and *Juniperus* disappears. The contribution of the NAP and Polypodiaceae is smaller.

HISTORY OF VEGETATION

The deposits containing the fossil flora accumulated in a small, shallow water basin. No sporomorphs were found in the silty sands enclosing a thin layer of peat and organic silts at the depths of 2.5–2.4 m, deposited above the clayey and sandy succession. The succeeding fine-grained sands and silts, at 2.4–1.8 m depth, also provided no pollen. This part of the profile may indicate poor plant cover, characteristic of cold cli-

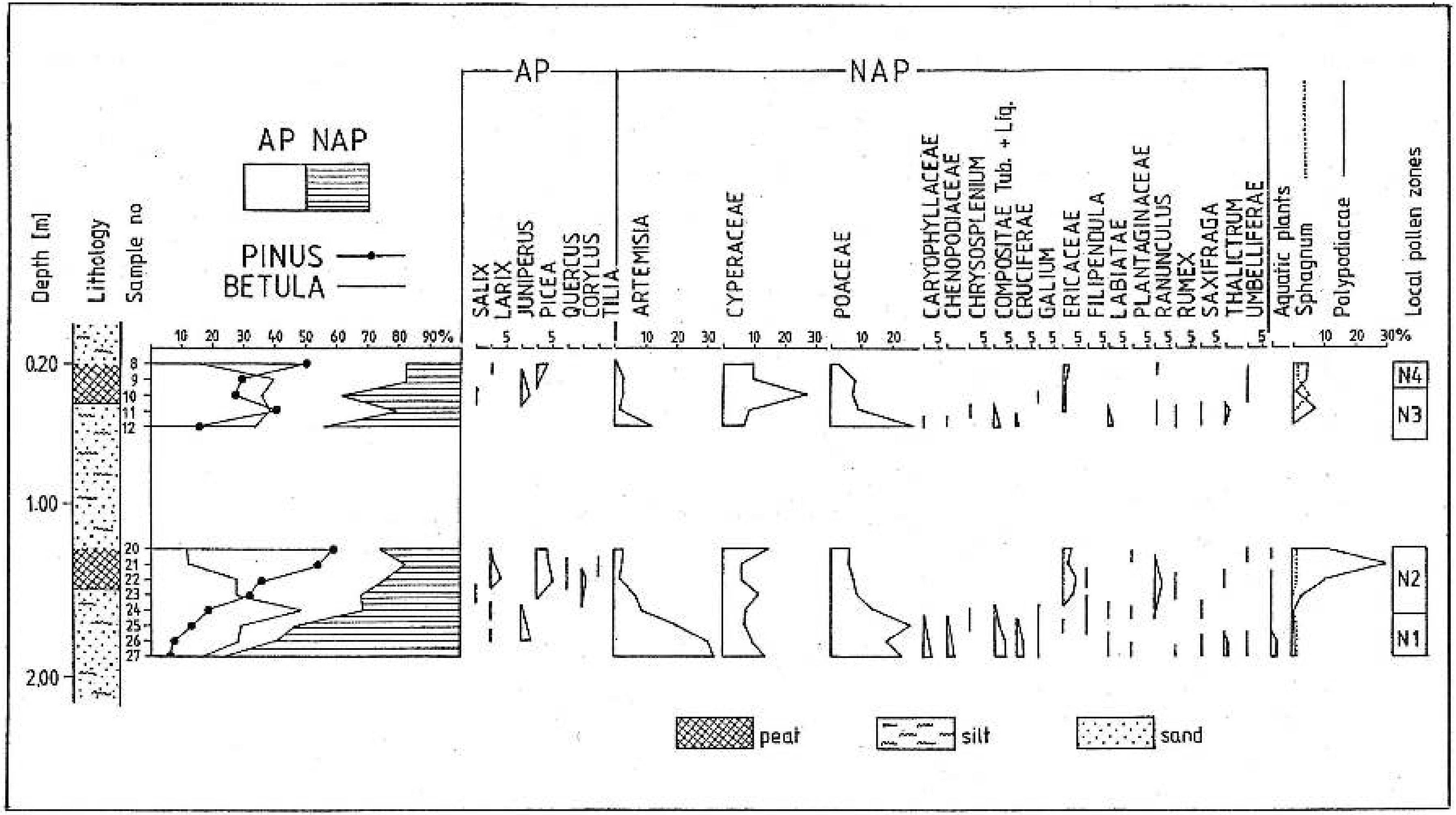

Fig. 3. Pollen diagram of sediments from Jutrosin

mates. Spore and pollen were recorded in sands and silts only at a depth of 1.8 m (L PAZ N1). Non-arboreal plants predominated at this time. The area around the basin was probably open tundra with herbaceous plants, as suggested by the high value of NAP with a considerable predominance of *Artemisia*, Poaceae and Cyperaceae. Small patches of scarce forest might have existed further away from the basin. The character of vegetation indicates that the N1 zone deposits accumulated in periglacial conditions. High values of *Artemisia* and Poaceae reveal that the climate was severe but not arctic, with continental features, which enabled the development of fairly thick vegetation — probably pioneering communities of *Artemisia*, grasses and sedges as well as patches of shrub tundra with *Betula* (probably *B. nana*), *Juniperus* and Ericaceae.

During the accumulation of the organic deposits (L PAZ N2), forest concentrations consisting of pine and birch with some spruce and larch appeared around the investigated site. A decreased contribution of herbaceous plants and the small variety of taxa testify to the increasing density of forests and climatic amelioration. The appearance of spruce (4.3%) indicates a humid climate (Obmiński, 1977). A considerable predominance of pine over other tree taxa may also indicate that the temperature of the warmest month was as high as 12°C.

In the succeeding N3 zone, pine and birch were still present in forests while the proportion of herbaceous plants increases. The change is due mainly to a higher percentage of Cyperaceae and Poaceae. A low pollen frequency and a small number of indigenous taxa seem to indicate an extremely poor flora and an almost complete absence of aquatic plants in the basin. The pollen spectra presumably represent open herb communities while the sedimentation of the silty deposits occurred in a relatively stable climate.

The top part of the profile (L PAZ N4) is predominated by pine and birch forests with spruce and juniper. Low values for herbaceous plants indicate dense forest and an improvement in climatic conditions in relation to zone N3, accompanied by a transition from lacustrine to peat sedimentation. The conditions of the sedimentation were comparable to those in other interstadials. High humidity and considerable rainfall resulted in clastic deposition with peat beds in local depressions (Mojski, 1993).

DISCUSSION

The succession of changes in vegetation and climate described is characteristic of an interstadial. Palynological analysis itself is not sufficient for a precise age determination and for this consideration of geological context and radiocarbon dates are needed. Sandy and silty deposits, which are pollen-free in the bottom part of the profile, and brown silts of the oldest pollen zone N1, accumulated in a cold climate. A considerable predominance of herbaceous plants in this zone indicates the absence of any patches of forest.

In the succeeding N2 zone, comprising peat, the pollen flora indicates a moderately cold climate, at first humid and then arid. The age of these bed was determined by radiocarbon dating as 29 000±1000 years BP. This date corresponds with the Denekamp Interstadial (Mojski, 1993).

After a cold period, the climatic conditions improved and sedimentation of peat deposits began. The age of peat in this section of the profile determined by ^{14}C as 28 500±950 years BP, corresponds to the end of the Denekamp Interstadial lasting from 32 000 to 28 000 years BP (Mojski, 1993). The fragment of the profile analysed suggests that the region of Jutrosin was at that time within the range of a forest — tundra plant community, as indicated by spectra with a decisive predominance of AP over NAP. It cannot be ruled out that in the open landscape some of the pollen could have been transported over long distances.

Deposits of a similar age dated to 31 400±1100 BP have only been found near Kępno (Rotnicki and Tobolski, 1965, 1969), about 65 km south-east from Jutrosin.

CONCLUSIONS

The sedimentary succession in the closed basins near Jutrosin dates back to the Vistulian Glaciation. The predominantly clastic succession is clearly bipartite. In the Nadstawe site, clays and clayey sands occur in the lower part of the profile, where in the many places overlying sands and silts with lenses of organic material interdigitate with them. This suggests that the succession filling the closed basins was formed in a single sedimentary cycle but in different climatic conditions.

The sandy and clayey deposits beginning the geological profile are not morainic despite their close resemblance to flow tills. They were formed in a cold climate, probably the early pleniglacial, which is suggested by an almost complete decalcification of the deposit, considerable weathering of the crystalline rock cobbles and, primarily, by the presence of frost structures. Around Jutrosin the material accumulated in the basins came from denudated morainic hills. The organic silt strata within the sandy lens may indicate a temporary amelioration.

The deposits described above are macroscopically similar to the flow tills found at the foot of the Łódź Plateau near Biesiekierz (Klatkowa, 1993, 1994), as substantiated by the majority of parameters determined in the laboratory. This supparts the hypothesis that diamictite overlying the Eemian organic series near Łódź is not of glacial origin (Klatkowa, 1993). The clays at Biesiekierz from the top of the local depressions, similar to Jutrosin, are probably of Vistulian age, as indicated by their stratigraphic position.

The sedimentation of the upper unit (N4 zone) was accompanied by a gradual warming of the climate. The lowest organic stratum without pollen material dated to *ca.* 39 000 years BP may correlate with the Hengelo Interstadial, the age of which in western Europe was determined as 39 000–36 000 years BP (Mojski, 1993). The absence of spore and pollen material makes it impossible to reconstruct the succession of the vegetation. The N1 zone may be interpreted as a decline of this period. The palynology of the organic zones N2–N4 correlates with the results of ^{14}C dating and indicates that these deposits relate to the Denekamp Interstadial, *ca*. 29 000–28 000 years BP.

In Poland there are many sites of fossil floras representing interstadial fragments from the Plenivistulian (Mamakowa and

Środoń, 1977; Balwierz, 1995; Środoń, 1987*a, b*). In the south of Wielkopolska this part of the Vistulian has been palaeobotanically described in the Barycz valley near Dyminy and Suliradzice (Krzyszkowski and Kuszell, in preparation). The vegetation from Jutrosin does not differ considerably from other contemporary sites in the neighbouring areas (Rotnicki and Tobolski, 1965). In the other floras from different parts of Poland there are similar pollen spectra of boreal vegetation. Herbaceous plants are of much significance, especially grasses, sedges, steppe helophytes with the predominanting genus *Artemisia*. The preserved flora from Jutrosin generally reflects two intervals of moderately cold climate with a small fluctuation showing a temporary deterioration of climate. In the Denekamp Interstadial southern Poland was covered by park tundra with *Betula, Pinus, Salix* and *Larix*. The climate of the Denekamp Interstadial was interpreted from floristic investigation of the deposits from southern Poland (Mamakowa and Środoń, 1977); these authors quoted average temperatures in July at least 2–3°C higher than that assumed for the Netherlands and Germany, reaching *ca*. 13°C, as indicated by the presence of *Pinus sylvestris* and *Betula verrucosa*.

The profile investigated did not provide any pollen spectra that reflect the deterioration in climate at the end of the Denekamp Interstadial.

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