Geological Quarterly, Vol. 39, No. 1, 1995, p. 109–120

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Mazovian (Holsteinian) lake sediments at Woskrzenice near Biała Podlaska

During the Mazovian (Holsteinian) Interglacial a lake district existed in eastern Poland. Palynological analyses proved that deposition in the lakes occurred during the whole interglacial until the Odra (Saalian) Glaciation. Lacustrine sediments contain remnants of several plants which have not been noted previously for the Holsteinian Interglacial, and they may be index taxa for it. Occurrence and distribution of buried lakes is connected with faults and tectonic grabens. Origin of lakes is also discussed.

INTRODUCTION

Numerous sites of ancient sediments of the Mazovian (Holsteinian) Interglacial age have been studied in Poland (Fig. 1). Among them, a fragment of a lake district has been recently examined in southern Podlasie (Fig. 2). Glacial origin of lakes in this area is found to have been under intensive influence of bedrock tectonics. At the same time, relic floral elements and floral successions recorded in sediments were appreciated for their potential stratigraphic contents.

Fossil carbonate sediments at Woskrzenice were noted for the first time by J. Nitychoruk in 1989 and at Wilczyn by L. Lindner in 1990. Carbonate gyttja at Kaliłów was found by J. Nitychoruk and K. Bińka in 1993.

The described carbonate sediments occur in valley-like depressions of melt-out origin, with their base at about 140 m a.s.l. These depressions are surrounded by a glaciofluvial plateau and by kames, the tops of which are located up to 150–155 m a.s.l.

Boreholes in the vicinity of Wilczyn and Woskrzenice (drilled by the Geological Enterprise from Warsaw) were used to make a geological section of these sites. The section cuts a single meridional palaeolake, several kilometres long (Figs. 3, 4). At Wilczyn, carbonate sediments of this basin are over 30 m thick.

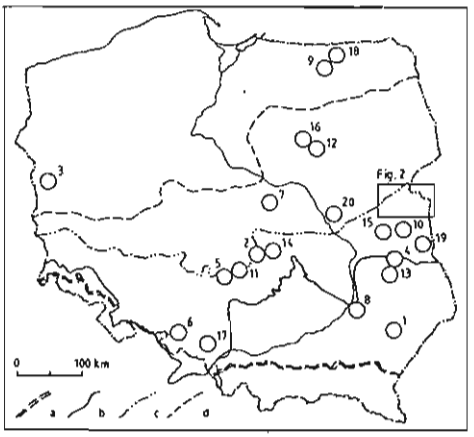

Fig. 1. Location of selected sites representing the Holsteinian Interglacial against extents of Scandinavian glaciations in Poland

Glaciations: a — Elsterian, b — Saalian, c — Warthanian, d — Weichselian; sites: 1 — Adamówka (K. Bińka *et al.*, 1987), 2 — Barkowice Mokre (M. Soholewska, 1952), 3 — Boczów (Z. Janczyk-Kopikowa, S. Skompski, 1977), 4 — Ciechanki Krzesimowskie (M. Brem, 1953), 5 — Dubidze Kolonia (Z. Borówko-Dłużakowa, 1981), 6 — Gościęcin (A. Środoń, 1957), 7 — Jamno (Z. Janczyk-Kopikowa, 1991), 8 — Karsy (D. Kosmowska-Suffczyńska, K. Szczepanek, 1981), 9 — Koczarki (Z. Borówko-Dłużakowa, W. Słowański, 1991), 10 — Krępiec (Z. Janczyk-Kopikowa, 1981), 11 — Kuców (D. Krzyszkowski, 1989), 12 — Maków Mazowiecki (M. Gołąbowa, 1957), 13 — Nowiny Żukowskie (J. Dyakowska, 1952), 14 — Olszewice (M. Sobolewska, 1956), 15 — Poznań (H. Winter, 1991), 16 — Przasnysz (A. Bałuk, K. Mamakowa, 1991), 17 — Stanowice (M. Sobolewska, 1977), 18 — Węgorzewo (M. Sobolewska, 1975), 19 — Włodawa (A. Stachurska, 1957), 20 — Wylezin (J. Dyakowska, 1956)

Lokalizacja wybranych stanowisk z interglacjału mazowieckiego (holsztyńskiego) na tle zasięgów zlodowaceń skandynawskich w Polsce

Zasięgi zlodowaceń: a — Elstery (Sanu), b — Solawy (Odry), c — Warty, d — Wisły; 1–20 — stanowiska (patrz tekst angielski)

PALAEOBOTANIC ANALYSIS

Two sections were analysed:

1. The Wilczyn section was sampled in a depression between the villages of Wilczyn and Grabanów. The five-metre long core contains lake marl, which passes upwards into shallow-water facies with a snail fauna and increasing clay content. The pollen diagram shows a climatic optimum and a post-optimum cooling.

2. The Woskrzenice section comprises an about nine-metre long sequence of deep-water sediments, mainly lake marl. It presents a vegetation history, that starts with predominating tundra communities and ends at a climatic optimum.

At first, these two sections were considered to come from two independent lake basins 7 km distance apart. But in a drilled-through elevation that separates them, deep-water lacustrine sediments have been found of a similar age to those at Wilczyn.

In a pollen diagram, seven local pollen zones and several subzones were distinguished (Fig. 5). Two periods are worth mentioning for the Quaternary stratigraphy:

I. The first two pollen zones record unquestionable tundra relations. The first local pollen assemblage zone contains sedges and grasses only. It represents presumably a mossy tundra area, just to the north of a bush tundra and an ice sheet possibly occurring a short distance further to the north. The second local pollen assemblage zone represents relations in an arctic bush tundra or perhaps in a subarctic area with *Polygonum viviparum*, *Selaginella selaginoides* t., *Saxifraga stellaris* t., *S. oppositifolia* t., *Thalictrum alpinum/minus*, *Centaurea cyanus*, *C. scabiosa* t. Such an image in Poland (except the first zone) is common at numerous sites. A considerably different picture is noted in recently

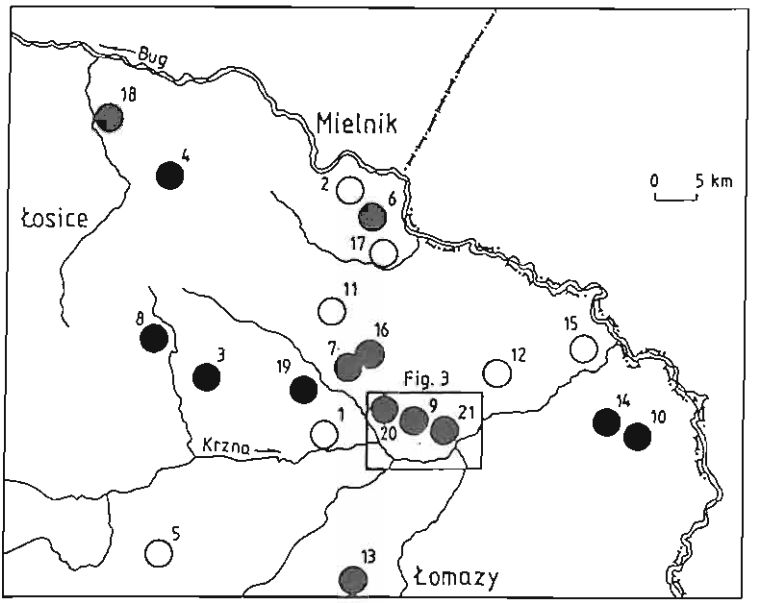

Fig. 2. Location of sites of the Holsteinian Interglacial in southern Podlasie after J. Nitychoruk (in press)
Sites: 1 — Biała Podlaska (K. M. Krupiński, 1984–1985), 2 — Borsuki (J. Nitychoruk, K. Bińka, 1994), 3 — Cyłujki, 4 — Czuchów, 5 — Drelew, 6 — Granna, 7 — Hrud (L. Lindner *et al.*, 1991), 8 — Huszlew, 9 — Kalilów (K. Bińka, J. Nitychoruk, this paper), 10 — Kobylany (W. Karaszewski, E. Rühle, 1976), 11 — Komarno (K. M. Krupiński, L. Lindner, 1991), 12 — Lipnica (K. Bińka, J. Nitychoruk, in press), 13 — Łomazy, 14 — Malaszewicze, 15 — Mokrany Nowe (K. M. Krupiński, J. Nitychoruk, 1991), 16 — Ossówka (L. Lindner *et al.*, 1990), 17 — Pawłów Nowy, 18 — Rusków, 19 — Terebella, 20 — Wilczyn (K. Bińka, J. Nitychoruk, this paper), 21 — Woskrzenice (K. Bińka, J. Nitychoruk, this paper); black circles mark carbonate sediments
Lokalizacja stanowisk z interglacjału mazowieckiego (holsztyńskiego) na południowym Podlasiu według J. Nitychoruka (w druku)
1–21 — stanowiska (patrz tekst angielski); czarnymi kółkami zaznaczono osady węglanowe

examined diagrams from Germany (B. Urban *et al.*, 1991). Several pre-interglacial climatic fluctuations (forest episodes inclusive) distinguished there, do not seem to be recorded in other pollen diagrams from Poland.

2. The second period, connected with intra-interglacial cooling (*Pinus – Larix* — subzone C), has predominantly pine-birch communities accompanied by larch. Similar cooling was previously noted by H. Müller (1974) in Germany. A drop of water level is noted in many lake reservoirs, which is expressed by changes in sediment facies and by hiatuses. This cooling is indicated in an extreme way in one of the sections by several-metre thick debris-flow deposits within the lacustrine interglacial series.

The post-optimum interval that is recorded in other sections indicates a gradual drop of temperature and transformation of forest communities, initially with predominating pine, spruce, fir and deciduous trees (with typical presence of *Pterocarya*). Still during the forest phase, steppe-like processes and an increasingly continental climate occurred, expressed by higher contents of *P. cembra* t., *Juniperus*, *Artemisia*, *Chenopodiaceae* and others, *pro*

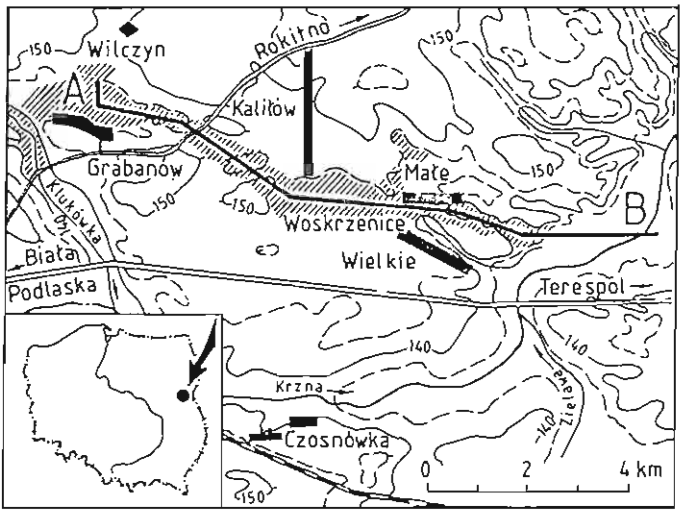

Fig. 3. Location sketch of the Wilczyn, Kaliłów and Woskrzenice sites with geological section A–B marked and area with buried basin sediments (hatchured)

Szkic lokalizacyjny stanowisk Wilczyn, Kaliłów i Woskrzenice z przekrojem geologicznym A–B wraz z zasięgiem basenu sedymentacyjnego (skośne kreski)

parte steppe plant types such as *Bupleurum*, *Thalictrum minus* t., *Valeriana tuberosa*, *Gypsophila fastigiata* t., presumably also by *Filipendula* (*hexapetala*?), *Plantago maritima* t., *Saussurea/Serratula* t., *Ephedra distachya* t. and *Helianthemum*. Halophilous types were noted in the basin. The forest-steppe formation was finally replaced by cool steppe communities of a continental climate, unfavourable to development of an ice sheet.

Presence of several plants which have not been noted previously or have been noted occasionally only for the Holsteinian Interglacial, are the interesting feature of the analysed pollen diagrams. It should also be indicated that high proportion of Tertiary or older sporomorphs is limited in the sections to a tundra phase only, whereas remaining sediments (about 75% carbonates and organic matter) are very reliable. Among such plants there are:

Hydrocotyle ranunculoides (Pl. I, Figs. 8–11) — at Wilczyn only three pollen grains of this type were noted (M. -Th. Cerceau-Larrival, 1980), comprising also *H. geraniifolia*. Size of the latter species (38 x 20 μ) excludes it from further considerations. Up to recent times, macrofossils of *H. ranunculoides* were noted for the Holsteinian Interglacial in Germany (J. Seelze-Stoller, 1919; M. Rochow, 1953) and Poland (M. Sobolewska, 1977). This species occurs at present in southern Europe (Flora Europaea), in the Caucasus, Iran and North America.

Hydrocotyle hirta type (Pl. I, Figs. 1–7) — a single pollen grain was noted at Wilczyn and four at Woskrzenice, strictly corresponding to the assemblage type (M. -Th. Cerceau-Larrival, 1980). They comprise *H. javanica*, *H. laxiflora*, *H. muscosa*, and *H. sibthrofoides* (the genus *Centella* has decidedly larger dimensions). This type can be easily distinguished from *H. vulgaris*, present in Europe, as it displays a sudden rise of the tectum at the poles. Strict systematic affiliation can be defined after macrofossils are found.

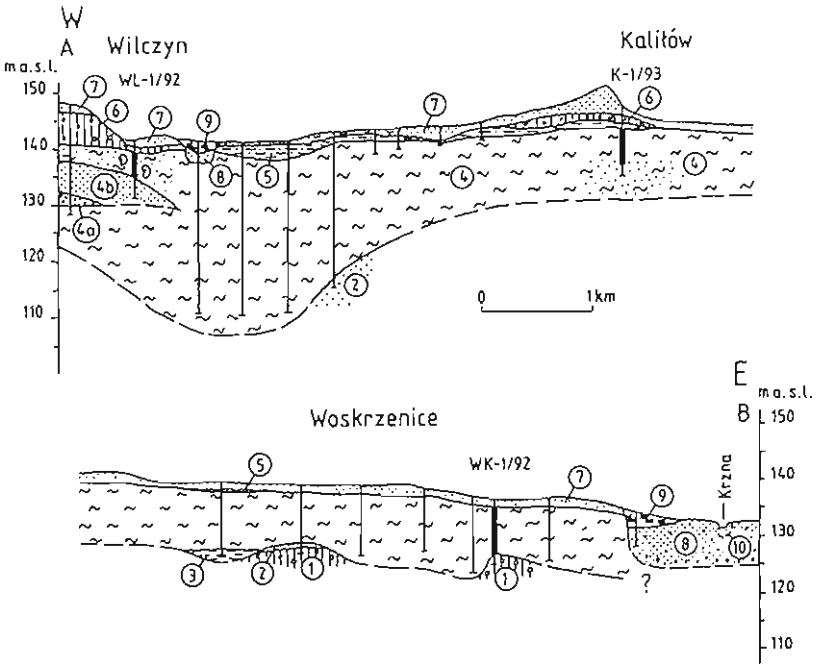

Fig. 4. Geological section A–B (location in Fig. 3) in Quaternary sediments of the Wilczyn, Kaliłów and Woskrzenice sites

Elsterian (San) Glaciation: 1 — till, 2 — medium and poorly sorted sands; Holstei-nian (Mazovian) Interglacial: 3 — silts, 4 — gyttja and lake marl, locally sandy, 4a — poorly sorted sands with gravel, 4b — medium-grained sands; Saalian (Odra) Glaciation: 5 — sandy silts, 6 — sandy till, 7 — medium and poorly sorted sands, locally clayey; Eemian Interglacial?, Weichselian Glaciation?: 8 — medium-grained sands with gravel; Holocene: 9 — peat, 10 — medium-grained sands; thick fragments of boreholes mark sampling sites of palynological analyses

Przekrój geologiczny A–B (lokalizacja na fig. 3) przez osady czwartorzędowe w stanowisku Wilczyn, Kaliłów i Woskrzenice

Zlodowacenie Sanu (Elstery): 1 — glina zwałowa, 2 — piaski średnio- i gruboziarniste; interglacjał mazowiecki (holsztyński): 3 — mułki, 4 — gytja i kreda jeziorna miejscami zapiaszczona, 4a — piaski różnoziarniste ze żwirem, 4b — piaski średnioziarniste; zlodowacenie Odry (Solawy): 5 — mułki piaszczyste, 6 — glina zwałowa piaszczysta, 7 — piaski średnio- i różnoziarniste miejscami ilaste; interglacjał eemski?, zlodowacenie Wisły?: 8 — piasek średnioziarnisty ze żwirem; holocen: 9 — torf, 10 — piasek średnioziarnisty; pogrubione odcinki otworów wiertniczych oznaczają miejsca pobrania próbek do analiz

Lycopodium lucidulum type (Pl. I, Figs. 12–16) — appeared in warm intervals in all the sections. There are spores, morphologic types of which correspond to numerous species (*L. serratum and others)* with longer arms compared to *L. selago*. It seems symptomatic that such spore, a strict classification of which is not possihle, does not appear in cool periods (post- and pre-interglacial ones) but in warm interglacial phases.

Parrotia type (Pl. I, Figs. 17–23) — the most interesting find forms a continuous pollen curve of a plant that undoubtedly belongs to the family Hamamelidaceae. The pollen

diagram indicates that the climax of this plant's occurrence is connected with the maximum of warm-loving plants such as *Vitis*, *Buxus*, *Celtis* and *Abies* (climatic optimum — pollen zone *Carpinus-Abies*). This pollen type (3-colpata or rare 4-colpata) is highly similar in its reticulum and other features to the genus *Parrotia*, *Fortunearia* and *Sinowilsonia* (this genus is less similar — too large size of fossil grains). Rare polyporata pollen grains correspond in turn to one of the species of the genus *Sycopsis* (Chang Tsin-tan, 1964) and due to quite abundant occurrence can play a significant stratigraphical role in age diagnosis of the sediments.

STRATIGRAPHIC SETTING

Age of the Pleistocene palaeofloras is most frequently defined on the basis of their typical successions. It was found, however, that such an argument is not always sufficient for evaluation. The floras defined as Eemian have not been found in every case to be probably of the same age. In spite of similar succession, a decided role was played by composition of macrofossils with numerous taxa absent in the Eemian flora (O. P. Kondratiene, 1973; O. P. Kondratiene, E. Wiszniewska, 1974; K. M. Krupiński, L. Marks, 1986; K. Erd, 1987; F. J. Wieliczkiewicz, 1982; D. H. Mai, 1990). In the case of the Mazovian Interglacial such a situation seems to be extensive. Its course is more complex with outlined intra-interglacial cooling. For a long time, numerous exotic taxons have been noted in pollen-spore floras of the Holsteinian Interglacial. They are abundant (which is also a diagnostic feature), e.g., *Celtis*, *Pterocarya*, *Buxus*, *Syringa*, *Ligustrina amurense* t., *Vitis*, *Osmunda cinnamomea* and *Azolla* (K. Erd, 1966; C. Turner, 1970, and others). There is abundant macrofossil flora with numerous extinct taxa or ones coming from far-distant areas of the Holarctic: *Aracites*, *Sisyrynchium*, *Scirpus*, *Brasenia*, *Caulinia* and *Crataegus* (M. Aalto *et al.*, 1992; D. H. Mai, 1988; M. Sobolewska, 1977; F. J. Wieliczkiewicz, 1982; W. H. Zagwijn, 1978, and others).

A typical succession of analysed sections, with numerous exotic index plants (also with megaspores of *Azolla*) seems therefore to be sufficient evidence to correlate it with the Holsteinian Interglacial type. Numerous pollen sequences of the latter were already noted in the European Lowland (H. Müller, 1974; K. J. Meyer, 1974; B. Urban *et al.*, 1991; A.-M. Robertsson, K. Garcia Ambrosiani, 1992; K. M. Krupiński *et al.*, 1986).

The palynological analysis of the section from Woskrzenice enables connection of its development with lacustrine carbonate deposition during the Holsteinian Interglacial. It seems therefore that the underlying till (1 in Fig. 4) and sands (2 in Fig. 4) come from the Elsterian Glaciation. Overlying silts (5 in Fig. 4), upper till (6 in Fig. 4) and sands (7 in Fig. 4) are evidence of the subsequent Saalian Glaciation. On the other hand, sands within the fluvial valleys (8 in Fig. 4) can be connected with deposition either during the Eemian Interglacial or the Weichselian Glaciation. During the Holocene, organic (9 in Fig. 4) and mineral (10 in Fig. 4) deposition occurred in the studied area (Fig. 4).

The described buried lacustrine basin is a fragment of a meridional row of depressions, filled with carbonate sediments formed during and after the Holsteinian Interglacial. In the east it runs across the Małaszewicze (14 in Fig. 2) and Kobylany (10 in Fig. 2) sites, whereas in the west — the Terebella, Cyłujki and Huszlew sites (19, 3 and 8 in Fig. 2). The mentioned

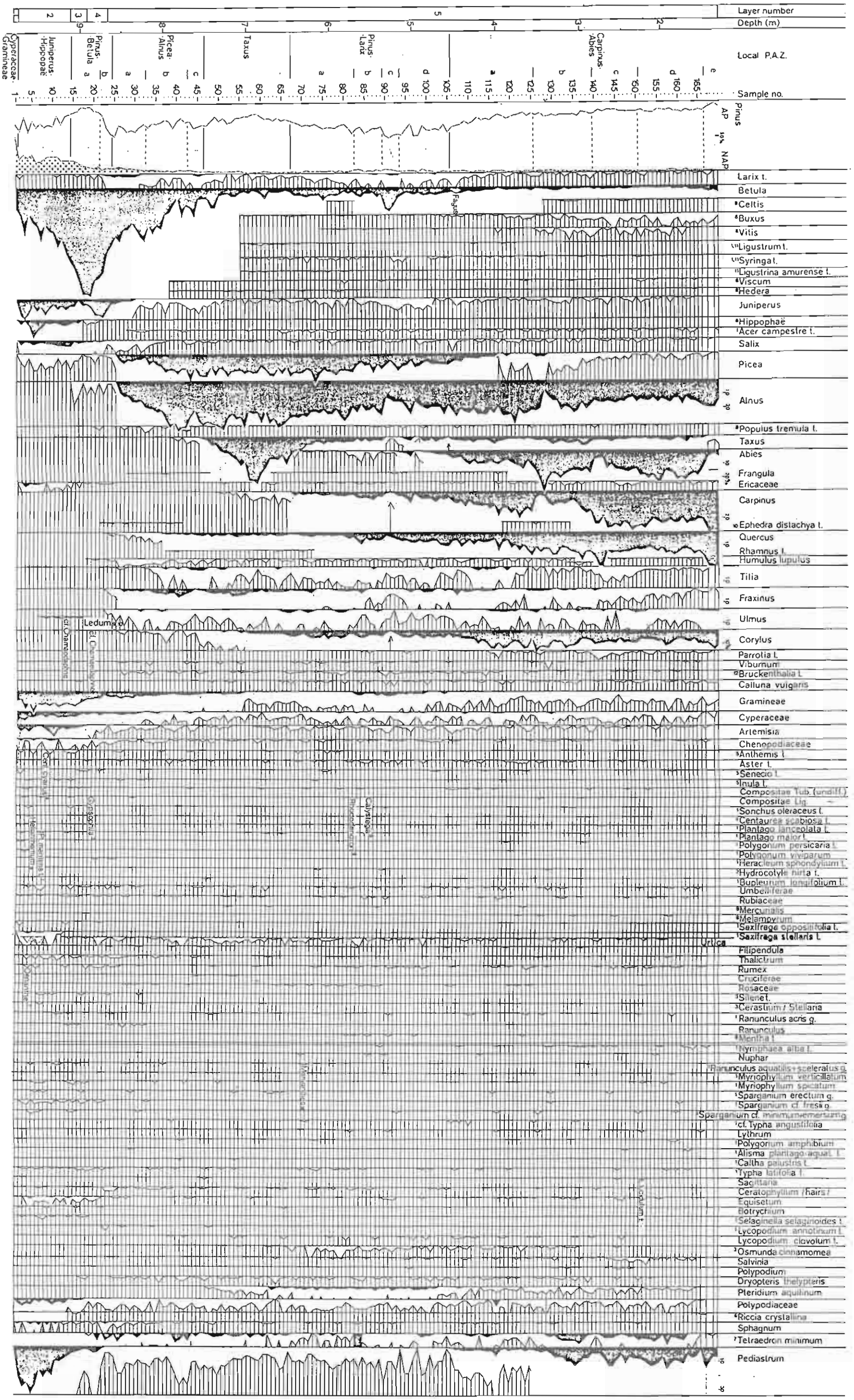

Fig. 5. Simplified pollen diagram of the Woskrzenice site

Layer number: 1 — peat, 2 — clay, 3, 5 — marl, 4 — sandy marl; 1–12 (superscripted index number): pollen grains determined according to: 1 — NEPF (The Northwest European Pollen Flora), 2 — WPSF (World Pollen and Spore Flora), 3 — Andersen (1961), 4 — Wagenitz (1955), 5 — Stix (1960), 6 — Rejment-Grochowska (1966, 1971), 7 — Ralska-Jasiewiczowa (1992), 8 — Faegri-Iversen (1978), 9 — Oldfield (1959), 10 — Beug (1961), 11 — Grüger (1967), 12 - Behre (1974)

Uproszczony diagram palinologiczny stanowiska Woskrzenice

Numery warstw litologicznych: 1 — torf, 2 — ił, 3, 5 — kreda jeziorna, 4 — kreda piaszczysta; 1 –12 — cyfry w indeksie górnym przy nazwach pyłków (patrz tekst angielski)

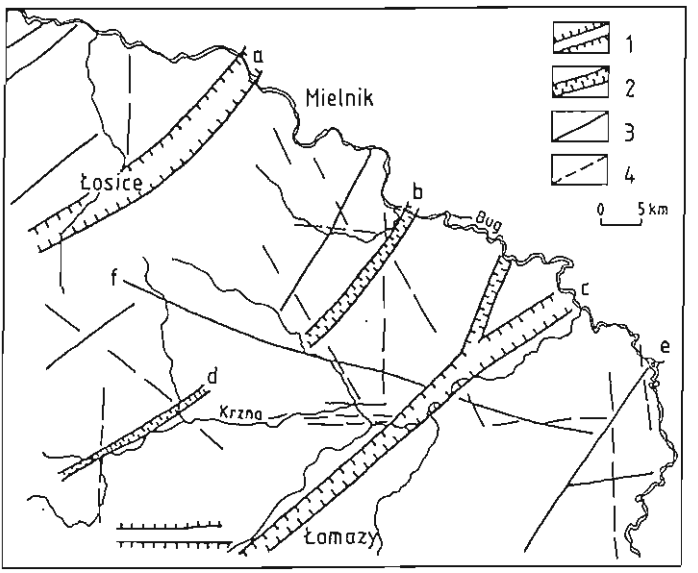

Fig. 6. Main tectonic structures of the pre-Quaternary bedrock in southern Podlasie after W. Pożaryski (1974), A. M. Żelichowski (1972, 1974) and J. Nitychoruk (in press)

1 — tectonic horsts, 2 — tectonic grabens, 3 — main faults, 4 — secondary faults; a — Łosice Graben, b — Janów Podlaski Graben, c — Biała Podlaska Graben, d — Międzyrzec Podlaski Graben, e — Terespol Fault, f — Kobylany – Huszlew Fault

Główne struktury tektoniczne w podłożu czwartorzędu na południowym Podlasiu według W. Pożaryskiego (1974), A. M. Żelichowskiego (1972, 1974) i J. Nitychoruka (w druku)

1 — zręby tektoniczne, 2 — rowy tektoniczne, 3 — główne uskoki, 4 — uskoki drugorzędne; a — rów Łosic, b — rów Janowa Podlaskiego, c — rów Białej Podlaskiej, d — rów Międzyrzecza Podlaskiego, e — uskok Terespola, f — uskok Kobylan – Huszlewa

depressions are oblique to and connected with elongated basins of buried reservoirs with carbonate sediments at Ossówka and Hrud (16 and 7 in Fig. 2), the location of which correlates to deep tectonic depressions in the deep bedrock (Fig. 6). Probably, distinct directions of lakes of the meridional complex are also connected with tectonic fractures in the bedrock which have however, not been, known up to recent times.

The abovementioned sites of fossil lacustrine sediments in southern Podlasie (Fig. 2) indicate numerous common features such as:

— similar types of sediments in carbonate facies,

— large thickness of lacustrine sediments (over 30 m),

— location and run of lakes corresponds to tectonic structures in the deep basement,

— lack of distinct stratigraphical hiatuses in lacustrine sediments of the Holsteinian Interglacial and the following cool interval before the successive glaciation (Saalian).

These facts indicate that in tectonic grabens, continuous subsidence occurred at that time. General mechanism of lake development during the Holsteinian Interglacial can be presented in the following way. Areal melting of the ice sheet of the Elsterian Glaciation in active tectonic zones resulted in disintegration into dead-ice blocks that persisted for longest time in tectonic depressions. Static loading by dead ice in tectonic grabens, accompanied

by glacioisostatic uplift of the whole area, resulted in subsidence of these grabens connected with increased deep-water pressure. The waters circulated upwards along the faults towards the surface, thus making melting of the ice quicker. After final deterioration of dead-ice blocks, water reservoirs were formed in depressions. In tectonic zones, they tended to subside during the whole interglacial until the successive glaciation.

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Received: 05.08.1994

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Krzysztof BIŃKA, Jerzy NITYCHORUK

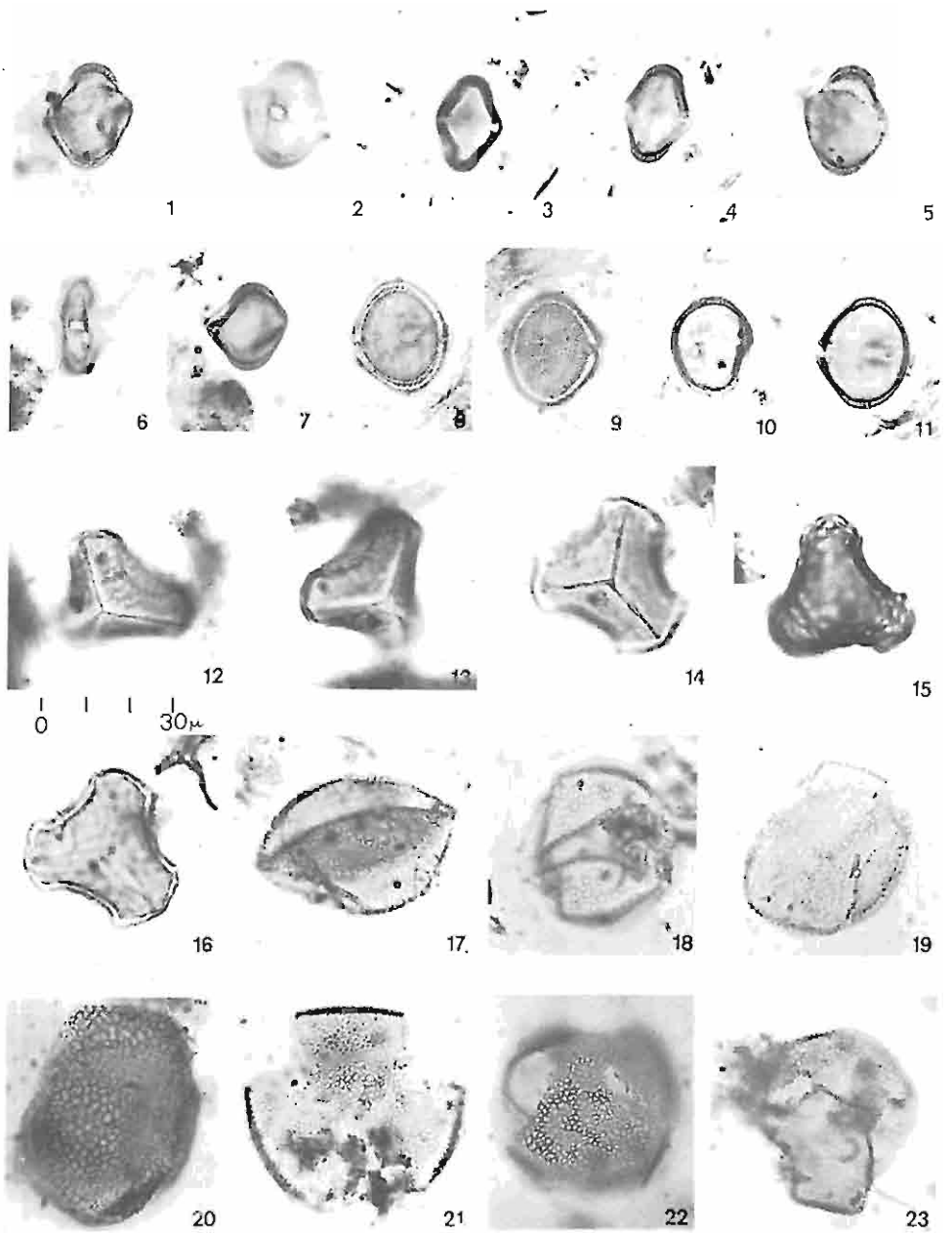
ORGANOGENICZNE OSADY INTERGLACJAŁU MAZOWIECKIEGO W WOSKRZENICACH K. BIAŁEJ PODLASKIEJ

Streszczenie

W Woskrzenicach k. Białej Podlaskiej stwierdzono miąższe osady jeziorne, których wiek, metodą paleobotaniczną, określono na interglacjał mazowiecki. Osady te, na które składa się przede wszystkim kreda jeziorna, są interesujące z kilku powodów. Po pierwsze wiążą się z ochłodzeniem wewnątrzinterglacjalnym, notowanym tylko w jednym jak dotychczas publikowanym diagramie pyłkowym, wyrażającym się dominacją lasów sosnowo-brzozowych z modrzewiem. Po drugie związane są z pojawieniem się w diagramie pyłkowym roślin nie lub rzadko notowanych, które mogą mieć potencjalne znaczenie stratygraficzne; są to: *Hydrocotyle hirta* t., *H. ranunculoides*, *Lycopodium lucidulum* t. i *Parrotia* t. Szczególnie ciekawe jest pojawienie się przedstawiciela rodziny Hammamelidaceae, ze względu na jego obfite występowanie. Po trzecie kształty wielu holsztyńskich zbiorników kopalnych na Podlasiu (również jeziora w Woskrzenicach), prześledzone na podstawie wielu otworów wiertniczych, wskazują na ich powiązania ze strukturami starszego podłoża i możliwości migracji wód podziemnych wzdłuż stref dyslokacji.

PLATE I

Fossil pollen grains (Wilczyn and Woskrzenice sites)
Kopalne ziarna pyłku (stanowiska Wilczyn i Woskrzenice)
Figs. 1–7. *Hydrocotyle hirta* typ
Figs. 8–11. *Hydrocotyle ranunculoides*
Figs. 12–16. *Lycopodium lucidulum* typ
Figs. 17–23. *Parrotia* typ



Krzysztof BIŃKA, Jerzy NITYCHORUK — Mazovian (Holsteinian) lake sediments at Woskrzenice near Biała Podlaska