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Geological and palaeobotanical setting of interglacial sediments at the Kaliłów site in southern Podlasie

The paper presents the results of pollen and geological analyses from the fossil lake sediments at Kaliłów near Biała Podlaska. In pollen diagram 8 local pollen zones are distinguished, starting with the shrub tundra through the *Pinus-Betula* woodland and typical Mazovian Interglacial succession and finishing with plant communities with abundant heliophythes. Palaeolake district is believed to be associated with linear tectonic structures of pre-Quaternary substratum because of narrow and long, up to several tens of kilometres, palaeolake depressions filled with sediments of impressive thickness, locally more than 30 m.

INTRODUCTION

Interglacial sediments at Kaliłów were drilled for the first time by K. Bińka and J. Nitychoruk in 1993, with a use of the Eijkelkamp corer. This drilling was to find whether a connection exists between two segments of a palaeolake (Fig. 1), studied previously at the sites Wilczyn (S. Szymański, 1992; J. Nitychoruk, 1994; K. Bińka, 1994) and Woskrzenice (J. Nitychoruk, 1994; K. Bińka, 1994; K. Bińka, J. Nitychoruk, 1995), and separated at present by the elevation. At first, a borehole to 9.5 m depth was done and the collected core was subdivided into 10 cm long fragments, used for a palaeobotanical analysis (K. Bińka, 1994). This borehole was deepened in 1994 to 15 m and the collected core was sampled at every 5 cm, analysis of which supplemented a palynological picture.

The core started from the top with a thin (0.3 m) humus layer, than by medium-grained sands (1.2 m thick), clayey till (0.5 m) and silts, more and more rich in $CaCO_3$ downwards, passing into occasionally sandy gyttjas and lake marl. Geological section along the depression with ancient lake sediments indicated (Fig. 2) that a system of parallel depressions occurs 5–10 m beneath surfaces of surrounding morainic plateaux — composed of tills, sands, gravels, and silts, many a time with sandy interbeddings. Carbonate sediments in

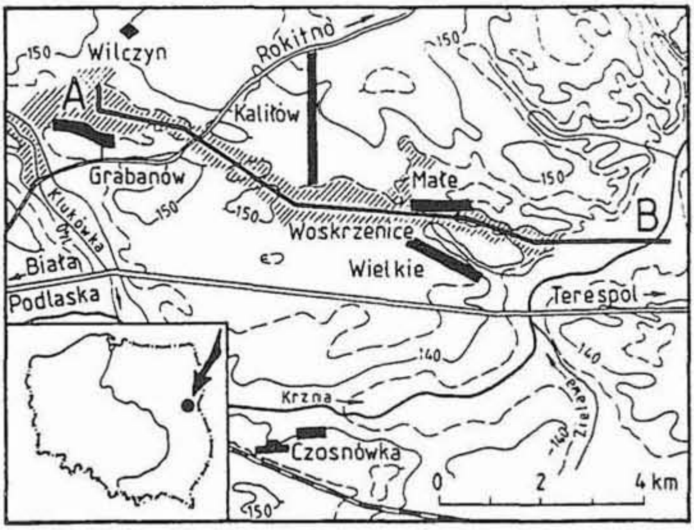

Fig. 1. Location sketch of the Wilczyn, Kaliłów and Woskrzenice sites with geological section A–B marked and area with buried basin sediments (hatchured)

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

depressions are underlain by a till (1 in Fig. 2), occasionally by medium- and vari-grained sands (2 in Fig. 2). At first, deposition of gyttja and lake marl was preceded by development of laminated clays and silts (3 in Fig. 2). The latter were deposited during melting-out of dead-ice blocks after a glaciation. A beginning of the interglacial lake deposition in the Kaliłów section is noted in sandy-silty sediments which contain some organic matter (at depth of 14.05–14.35 m) and pass upwards into clayey-silty series (13.9–14.05 m), with more and more calcium carbonate, changing finally into lake marl and gyttja. During deposition of carbonates in the reservoir, mass movements on sandy-gravel and tilly slopes occurred — at present they are noted as interbeddings in a palaeoshore zone (4 in Fig. 2). At depth of about 5 m contents of calcium carbonate decreases and the top of this series (3.5 m) is overlain by silts and clays (5 in Fig. 2), deposition of which is presumably connected with the following cool interval — just before ice sheet advance. The latter is indicated by thin till layers (6 in Fig. 2) and glaciofluvial sands (7 in Fig. 2).

The following fluvial erosion and accumulation are recorded by sands, sands with gravels and peats (8–10 in Fig. 2) within fluvial valleys and palaeolake depressions.

PALAEOBOTANIC ANALYSIS

Preliminary evolution of vegetation of the Mazovian Interglacial age for the Podlasie region is presented. Such examination was possible, among others due to a favourable

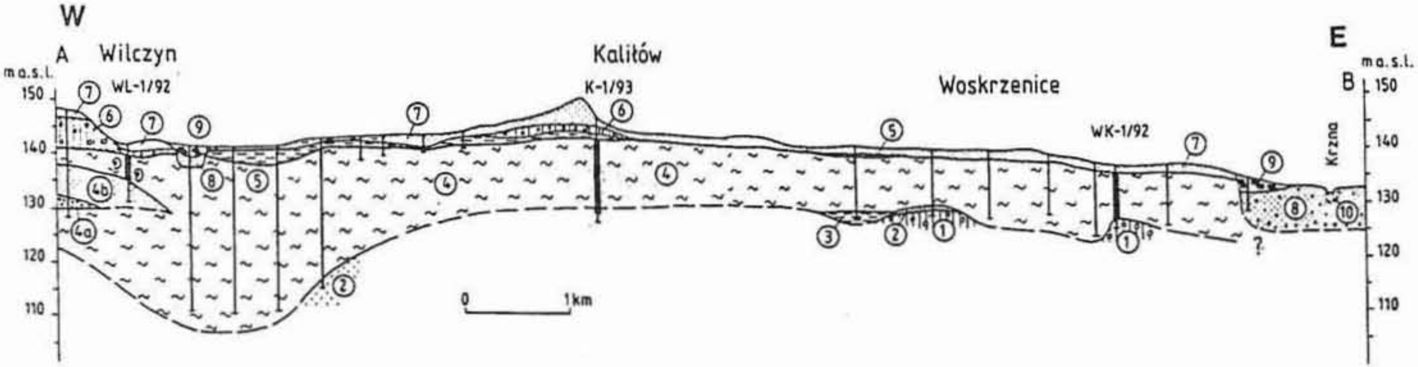

Fig. 2. Geological section A–B (location in Fig. 1) in Quaternary sediments of the Wilczyn, Kaliłów and Woskrzenice sites (after K. Bińka, J. Nitychoruk, 1995)

San (Elsterian) Glaciation: 1 — till, 2 — medium and poorly sorted sands; Mazovian (Holsteinian) Interglacial: 3 — silts, 4 — gyttja and lake marl, locally sandy, 4a — poorly sorted sands with gravel, 4b — medium-grained sands; Odra (Saalian) 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; WL-1/19 — symbol, number and year of drilled borehole

Przekrój geologiczny A–B (lokalizacja na fig. 1) przez osady czwartorzędowe w stanowisku Wilczyn, Kaliłów i Woskrzenice (według K. Bińki, J. Nitychoruka, 1995)

Zlodowacenie sanu (elstery): 1 — glina zwałowa, 2 — piaski średnio- i gruboziarniste; interglacjał mazowiecki (holsztyński): 3 — mułki, 4 — gytia 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 palinologicznych; WL-1/19 — symbol, numer i rok wykonania otworu lithology of the sequence for a pollen analysis. Sediments contained mostly carbonate facies that, except for a littoral zone, excluded stratigraphical hiatuses in the cores. Previous publication presented the section at Woskrzenice (K. Bińka, J. Nitychoruk, 1995), vegetation of which started from a pre-interglacial tundra to termination of the climatic optimum (phase fir-hornbeam). Among the unpublished sections, the most important is an inshore one from Wilczyn, with a post-interglacial sequence which is exceptionally short (K. Bińka, 1994). Examination of another core from Kaliłów (with a similar succession as at Wilczyn) presented a pollen diagram with vegetation evolution during the whole Mazovian Interglacial. The core comprises floristic succession from a pre-interglacial tundra to pine-birch communities at the end of the interglacial. It is therefore a valuable supplement to the section at Woskrzenice. In total, 8 pollen zones were distinguished, 7 of which represent interglacial succession.

PRE-INTERGLACIAL SUCCESSION
(POLLEN TYPES NOTED ONLY IN WOSKRZENICE ARE INDICATED BY W)

Juniperus-Hippophaë **L PAZ (2)** (Kaliłów — samples 1–4, Woskrzenice — samples 2–14). This pollen zone starts with bushes as juniper, sea-buckthorn and willows (various morphological pollen types, also arctic ones), and by numerous herbs. In this time, Podlasie was predominated by shrub communities. Except for the above-mentioned ones there were also *Betula nana* t., *Ericaceae* (*Ledum* included), *Ephedra distachya* t. NAP were quite abundant. Sedges, grasses, motherworts and *Chenopodiaceae* prevailed. *Silene* t. (W, *S. acaulis* ?), *Cerastium/Stellaria* (W), *Plantago maior* (W), *P. maritima*, *Botrychium*, *Rumex acetosella*, *Gnaphalium* t. (W), *Senetio* (all occur in tundra now), the arctic-alpine plants — *Selaginella selaginoides*, *Saxifraga stellaris* t., *S. oppositifolia* t., *Polygonum viviparum* — also occur. Pollen grains of *Thalictrum* represent *T. minus/alpinum* t. It is more probably that in pollen spectrum occur *T. alpinum*. However, *T. minus* ssp. *minus*, according to Hegi (1963–1983), is noted as far as 61°N (Norway). The characteristic feature of this zone is occurrence the arctic-alpine species, which are absent in a post-interglacial sequence (Wilczyn). The species in pollen spectra of *Juniperus-Hippophaë* zone represent various index of maritime and continental climate (W. Rothmaler, 1988). The maritime climate is represented by *Selaginella*, *Saxifraga* and probably *Sparganium affine* (the curve of *Sparganium friesi* t.), the continental climate — *Juniperus* (k), *cf. Chamaedaphne* (k), *Betula nana* (subk). It seems, in comparison with a post-interglacial zone at Wilczyn, the climate of that time gets more maritime. There is no modern community which can be considered for an exact equivalent of the described one. Some of these plants are absent in a shrub tundra e.g. sea-buckthorn and *Ephedra distachya* in the arctic zone (W. Rothmaler, 1988) and some herbs with a more southern extent recently — *Helianthemum*, *Polygonum persicaria* t., *Rubiaceae*, *Inula* t., *Sonchus*, *Centaurea cyanus* and *C. scabiosa* t. Also local plants in this pollen zone (K. Bińka, 1994) p.p. not occur in the modern tundra communities. It seems however correct that plant communities of that time could highly correspond, in spite of undoubted individuality, to the tundra ones — predominated by shrubs. Therefore, mossy communities absent in this section (pollen zone 1 in Woskrzenice) were replaced by communities of a shrub tundra.

INTERGLACIAL SUCCESSION

Pinus-Betula **L PAZ (3)** (Kaliłów — samples 5–14, Woskrzenice — samples 15–24). This pollen zone starts with a drop of NAP (mainly grasses, sedges, motherworts and *Chenopodiaceae*), with simultaneous rise of birch to maximum 75%. It is also accompanied by lower participation of shrubs as *Salix* and *Hippophaë*. *Juniperus* behaves in another way: its content is stabile at the beginning but reaches highest values (about 11%) after climax. Some herbs of cool floras disappear but e.g. *Selaginella selaginoides* is present. The pollen zone 3 was subdivided into two subzones:

a — *Betula* (Kaliłów — samples 5–12, Woskrzenice — samples 15–21) with maximum values of birch (about 75%);

b — *Pinus* (Kaliłów — samples 13–14, Woskrzenice — samples 22–24) with climax of pine (to about 45%), initial part of a larch curve (3%) and maximum values of juniper (to 11%).

It is noteworthy that *Humulus* occurring in this pollen zone indicates some better climatic conditions than it can be concluded from pine-birch communities (boreal zone). Now *Humulus lupulus* is limited to the mediterranean-temperate zone (W. Rothmaler, 1988). In the pollen zone *Pinus-Betula*, a significant transformation of plant communities is noted. Shrub tundra is replaced by forest communities. In the subzone **a** birch forest predominates, in the subzone **b** — pine forest with admixture of larch and juniper. Within this pollen zone, systematic reduction of photophilous plants occurs — firstly of grasses, motherworts and *Chenopodiaceae*.

Picea-Alnus **L PAZ (4)** (Kaliłów — samples 15–27, Woskrzenice — samples 25–46). This pollen zone is predominated by alder and spruce, accompanied by high values of pine pollen. Amongst other trees there are initial fragments of curves of elm, ash and maple. This pollen zone is not uniform and therefore, it was subdivided into three subzones. They are distinct at Woskrzenice, but have no sharp boundaries at Kaliłów (particularly the subzone **c**).

a — *Larix-Pinus* (Kaliłów — samples 15–18, Woskrzenice — samples 25–32) with more larch (about 2%) and pine (to 40%), lower values of alder (regular rise to 17%) and spruce (maximum 7%); low curves of oak, ash and elm appear;

b — *Alnus-Fraxinus* (Kaliłów — samples 19–24, Woskrzenice — samples 33–42), delimited by a first interglacial climax of ash (5%), alder (about 30%) and elm (about 1.5%);

c — *Larix-Pinus* (Kaliłów — samples 25–27, Woskrzenice — samples 43–46) with *Larix* again (to 3%) and significant climax of pine (about 37%), accompanied by typical drop of values of elm, ash and alder.

This pollen zone, firstly due to significant participation of abundant boreal trees as pine, spruce and larch, indicates close reference to a boreal zone. However, presence of many plants as ash, maple, oak — being the ones of varying extents but associated with a zone of deciduous trees that loose their leaves in winter (W. Rothmaler, 1988) — indicates northern limits of this zone rather. Sequence of the distinguished subzones proves that the subzones **a** and **c** developed at somewhat continental climate (its intensity cannot be easily determined). In the subzone **b** there is climax of ash [(oz)]. Sporadically *Hedera* (oz) and *Viscum* [(oz)] occur that also indicates a marine climate. It seems that in the subzone **b** existed a better temperature conditions in comparison with **a** and **c**.

Taxus **L PAZ (5)** (Kaliłów — samples 28–42, Woskrzenice — samples 47–67). This pollen zone indicates considerable participation of yew, values of which reach to 25% AP, spruce (about 15–20%) and alder. After a certain drop, ash reaches a second interglacial maximum at the beginning of this pollen zone. Abundant yew is a diagnostic feature for the Mazovian Interglacial. Changing climate, firstly its marine character, caused expansion of yew in the Podlasie, and also development of communities with trees of greater moisture demands i.e. of spruce and alder. Ash had also favourable conditions. A sporadic occurrence of *Ligustrum* [W – (oz)], *Viscum* (W), *Hedera* (W), *Buxus* (oz), *Parrotia* t. indicate both the maritime climate and some better temperature conditions.

Pinus-Larix **L PAZ (6)** (Kaliłów — samples 43–70, Woskrzenice — samples 68–105). This varied pollen zone indicates higher values of pine (maximum 50%) at small maximum of larch and grasses. Values of hazel are doubled to about 5%, indicating numerous fluctuations. The pollen zone *Pinus-Larix* was subdivided into four subzones, different significantly in composition of the main taxons.

a — *Picea-Alnus* (Kaliłów — samples 43–49, Woskrzenice — samples 68–82); in a pollen spectrum, alder (about 25%) and spruce (to 15%) have still high values; curves of pine (36%) and hornbeam (2–3%) are higher; best conditions for development are for *Syringa* and *Ligustrina amurense* t.;

b — *Carpinus-Quercus* (Kaliłów — samples 50–57, Woskrzenice — samples 83–89); rise of values of oak (to 4%) and hornbeam (to 4%), drop of spruce (to about 10%) and to a lower degree of alder (about 20%); *Vitis* and *Buxus* are rare;

c — *Pinus-Betula* (Kaliłów — samples 58–61, Woskrzenice — samples 90–93); drop of values of most trees; there are only climaxes of pine (about 48%), birch (about 18%) and larch;

d — *Carpinus* (Kaliłów — samples 62–70, Woskrzenice — samples 94–105); this subzone is similar to the subzone **b**, but with a slightly larger content of fir (2–3%); *Vitis* and *Buxus* are rare.

The L PAZ 6 has continental character, indicated by pine and larch — predominant in the Podlasie. Continental character of this pollen zone is also underlined by rare pollen of *Bruckenthalia*, more frequent than in the neighbouring zones and considered for an index of continental climate (K. Tobolski, 1991). A rare occurrence of more thermophilic elements (*Ligustrum, Viscum, Hedera*) is probably caused p.p. by good light conditions.

Amongst the four distinguished pollen subzones, a cooling is recorded undoubtedly by the phase **c**. It is univocally proved by rising values of pine, climaxes of birch and larch, and simultaneous disappearance of most species of deciduous trees and thermophilous elements. Similar interglacial cooling as at Kaliłów and Woskrzenice was noted in Germany (H. Müller, 1974). Although the pollen subzones **a**, **b** and **d** are slightly varied if their temperature is concerned, in the subzone **b** presumably a small occasional rise of temperature occurred, probably connected with drying of habitats which were predominated by spruce and alder (therefore their curves drop). Such event could cause expansion of hornbeam and oak. Rise of the latter could be also due to favourable light conditions in forest communities of that time. In many lake sequences in Poland, there are sedimentary hiatuses or more shallow sediments were deposited during this interval. Therefore, recognition of this interval has been incomplete so far.

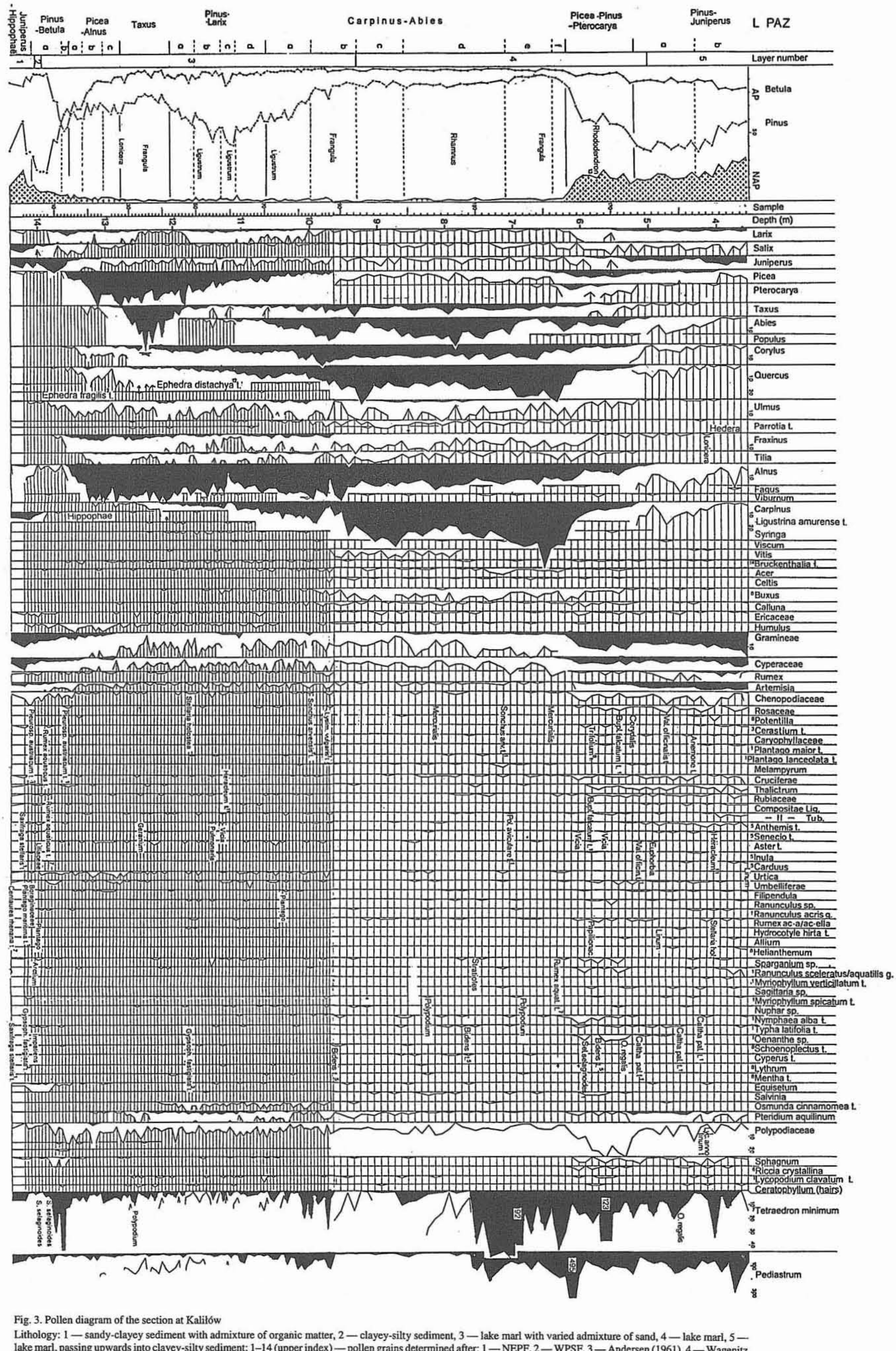

Fig. 3. Pollen diagram of the section at Kaliłów

Lithology: 1 — sandy-clayey sediment with admixture of organic matter, 2 — clayey-silty sediment, 3 — lake marl with varied admixture of sand, 4 — lake marl, 5 — lake marl, passing upwards into clayey-silty sediment; 1–14 (upper index) — pollen grains determined after: 1 — NEPF, 2 — WPSF, 3 — Andersen (1961), 4 — Wagenitz (1955), 5 — Stix (1960) p.p., 6 — Rejment-Grochowska (1966, 1971), 7 — Ralska-Jasiewiczowa (1992), 8 — Faegri-Iversen (1978), 9 — Grüger (1967), 10 — Behre (1974), 11 — *Heracleum/Pastinaca* after NEPF, 12 — Beug (1961), 13 — Oldfield (1959), 14 — Behre (1974)

Diagram pyłkowy profilu w Kaliłowie

Litologia: 1 — osad piaszczysto-mułkowy z domieszką materii organicznej, 2 — osad ilasto-mułkowy, 3 — kreda jeziorna ze zróżnicowaną domieszką piasku, 4 — kreda jeziorna, 5 — kreda jeziorna przechodząca stopniowo ku stropowi w osad ilasto-mułkowy; 1–14 (indeks górny) — ziarna pyłków oznaczone według autorów — patrz tekst angielski

Carpinus-Abies **L PAZ (7)** (Kaliłów — samples 71–123, Woskrzenice — samples 106–169). In this pollen zone the greatest area was occupied by fir, oak and hornbeam. Dynamics of curves of these taxons enabled to distinguish the following subzones:

a — *Carpinus-Corylus* (Kaliłów — samples 71–83, Woskrzenice — samples 106–125) indicates a constant rise of hornbeam and fir;

b — *Abies* (Kaliłów — samples 84–92, Woskrzenice — samples 126–139) distinguished on the basis of a rising curve of fir, at dropping contents of hornbeam and linden (single pollen grains);

c — *Quercus-Carpinus* (Kaliłów — samples 93–99, Woskrzenice — samples 140–150) forms a non-uniform subzone; the highest values are reached firstly by oak, then by hornbeam, at dropping content of fir; alder is more rare;

d — *Abies* (Kaliłów — samples 100–114, Woskrzenice — samples 151–166) next rise of fir, accompanied by high values of hornbeam and oak;

e — *Quercus-Carpinus* (Kaliłów — samples 115–121, Woskrzenice — samples 167–169) renewed climax of oak and hornbeam, with simultaneous quite a deep retreat of fir;

f — *Abies* (Kaliłów — samples 122–123) slight climax of fir, recorded in this very section only.

This zone indicates climatic optimum. Indicator plants as *Buxus, Vitis, Celtis*, presumably *Parrotia* t., *Salvinia, Viscum* (W), and also thermophilous fir, indicate maximum expansion. Climatic conditions in this zone are represented by mutual relations of fir from one side, and hornbeam and oak from the other. A fir is a thermophilous tree and therefore has higher thermal demands than other trees (T. Puchalski, Z. Prusinkiewicz, 1975). Its high temperature demands (also *Quercus* and *Carpinus*) coincide well with occurrence of other thermophilous species in a climatic optimum of the Mazovian Interglacial. Occurrence of *Abies* seems to have been determined by its moisture demands, quantitative as well as from a point of view of their regular occurrence (S. Białobok, 1983). A climate which formed favourable habitat conditions for a fir, should have marine features. The analysed zone indicated therefore cyclic moisture changes that favoured fir (subzone **b**, **d** and **f**) but at lower precipitation — oak and hornbeam.

Picea-Pinus-Pterocarya **L PAZ (8)** (Kaliłów — samples 124–133). This zone is represented by a rising curve of pine and drop of trees that predominated during a climatic optimum. A rise of curves of spruce (to 3–5%) and *Pterocarya* (to 4%) is noted for the same time. Rising curves of NAP include mainly sedges (4–5%) and grasses (10–15%), probably of local derivation, and *Artemisia*.

Bending of curves, although not so rapid as in the section at Wilczyn, seems to indicate a stratigraphical hiatus if compared with a preceding zone. During L PAZ 8, climatic conditions got worse as expressed by a more limited area occupied by indicator plants and trees as hornbeam, oak and fir. A more continental climate occurred in the same time, expressed by expansion of pine, larch and spruce, being more common in plant communities, and also of *Bruckenthalia*. In the lake are observed cyclic lowerings of water level (at the time of late summer or at longer time) and as a consequence-emergence of lake shores or periodic decline of lake.

Pinus-Juniperus **L PAZ (9)** (Kaliłów — samples 134–150) with two subzones (134–142 [**a**]; 143–150 [**b**]). In this zone, elimination or considerable delimitation in occurrence of most deciduous trees, as well as of fir and spruce occurred. Contents of pine and birch are

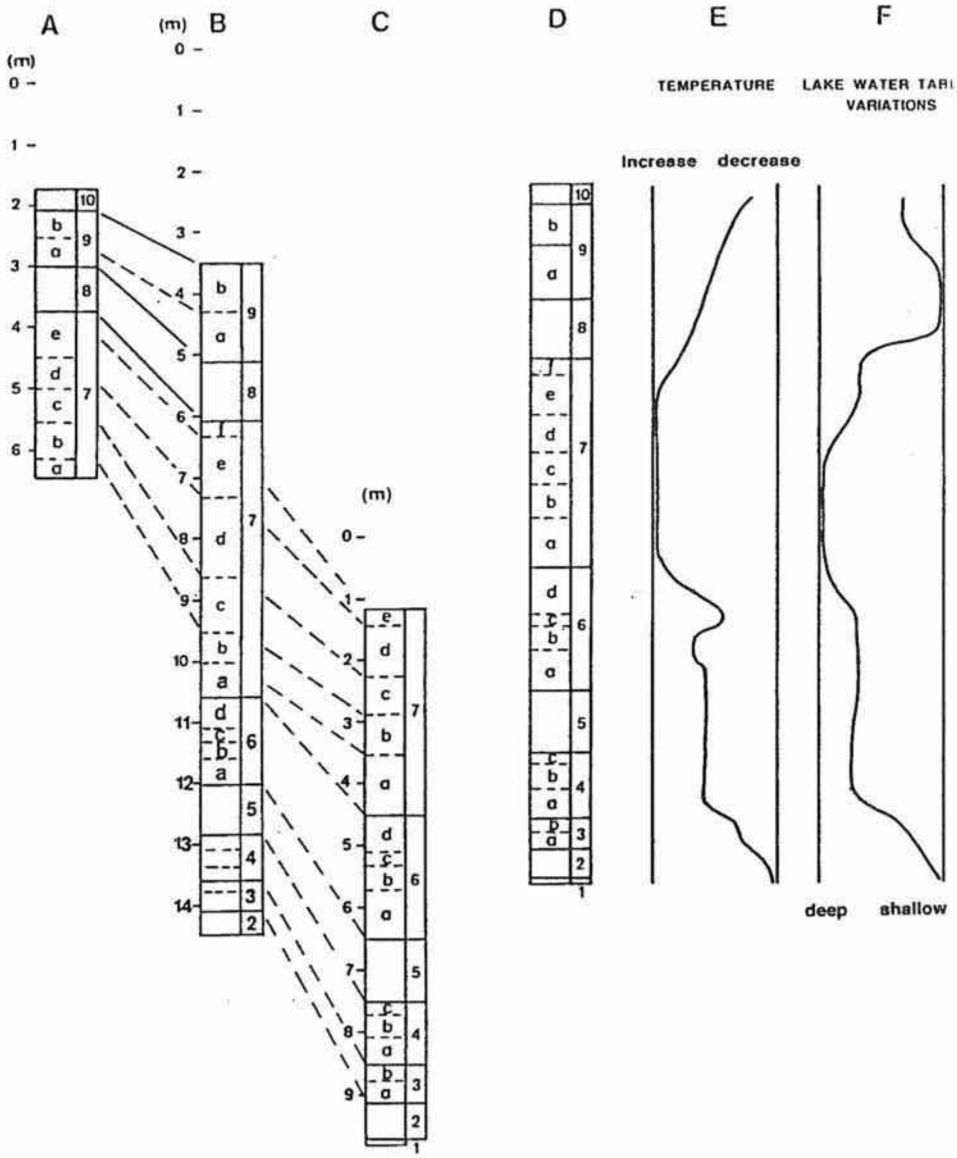

Fig. 4. Correlation of pollen zones in the sections: A — Wilczyn, B — Kaliłów, C — Woskrzenice, D — synthetic section with distinguished pollen zones and subzones, E — probable variation of air temperature, and F — water level in the lake

1–10 — pollen zones; a–f — pollen subzones

Korelacja poziomów pyłkowych wyróżnionych w profilach: A — Wilczyn, B — Kaliłów, C — Woskrzenice, D — syntetyczny rdzeń zbiorczy z zaznaczonymi poziomami i podpoziomami pyłkowymi, E — przypuszczalny przebieg wahań temperatury powietrza, F — wahania poziomu wody w zbiorniku

1–10 — poziomy pyłkowe; a–f — podpoziomy pyłkowe greater (to 40–50 and about 20%, respectively). In the subzone **a**, a continued rare occurrence of oak, hornbeam, fir and hazel is noted. In the subzone **b**, curves of these plants disappear, and simultaneously rise the ones of motherworts (to 6%), juniper (to 15%) and other photophilous plants.

Dropping temperature eliminated thermophilous species in the subzone **a**, with floristic relations similar presumably to the ones at boundary of boreal zone and temperate zones of deciduous trees. On the other hand, they are similar in the subzone **b** to conditions that predominate in a boreal zone. Climate gets more continental (*Pinus cembra* t., *Bruckenthalia*, *Larix* and *Juniperus*). There is characteristic participation of pollen types that can be connected with steppe grasses, at simultaneous absence of arctic-alpine plants. These types, more common in a shore section at Wilczyn (K. Bińka, 1994), indicate univocally open communities, although they can present a greater ecological variation. They belong to *Valeriana tuberosa*, *Bupleurum*, *Filipendula* (*hexapetala*?), *Thalictrum minus/alpinum*, *Botrychium*, *Saussurea* t. (presumably ?*steppe Serratula* sp.), *Helianthemum*, *Plantago maritima* t., also *Ephedra distachya* t. and *Selaginella helvetica*.

It is difficult to find present similar relations to the ones in this zone. As above-mentioned, they can be referred to a boreal zone of that time, and at the boundary of a boreal and temperate zone of deciduous forest. High content of heliophytes resembles a present forest-steppe or a considerably thinned forest, that have however better temperature relations and more rich species composition of trees. Such forest-steppe or thinned forest indicate therefore cooler conditions.

Top sediments from Kaliłów (as well as from Wilczyn) indicate that at abundant content of steppe vegetation and increased content of mineral matter there is only rare pollen in secondary deposit. Considerably another situation occurs in the bottom (particularly well noted at Woskrzenice) where clayey sediments of tundra environment contain abundant pollen in secondary deposit. Absence of the latter is connected with destruction during transport to a reservoir, together with a mineral material, due to cyclic wettening and drying when more steppe vegetation occurred (K. Bińka, 1994). Another situation is also possible when tundra communities predominate, what is also recorded in clayey-silty sediments (bottom). The environment was moister and no cyclic dryings occurred. The latter protected older pollen which entered a reservoir together with mineral material. Such image is noted in numerous sections of ancient lakes in Poland. A pollen diagram from Imbramowice indicates (K. Mamakowa, 1989) that secondary deposit is highly similar as at Kaliłów and Wilczyn. It seems also interesting that scheme of occurrence of plant communities just before and after the Mazovian Interglacial (tundra at the bottom of the community and steppe communities in the top) is the same as during the Eemian Interglacial (K. Mamakowa 1989; K. Tobolski, 1991; K. M. Krupiński, W. Morawski, 1993). Unfortunately, the three principal communities i.e. forest, tundra (connected with certain ice sheet activity) and steppe (unfavourable conditions for its development), distinguished in pollen diagrams (what was done among others by K. Tobolski, 1991, for the Vistulian), are not recorded in stratigraphical subdivisions done by the Quaternary geologists (glaciation, interglacial, stadial, interstadial).

Age of interglacial lake sediments results from typical floristic succession and presence of exotic elements. It seems obvious that analysed sediments come from the Mazovian Interglacial. It is distinctly proved by presence of a strong spruce interval with yew, the following phase with abundant pine during a typical cooling, as well as by interval with abundant fir and hornbeam. Exotics cannot point out univocally the age of sediments as their examination is different in each interglacial. However, among common plants there are: *Pterocarya, Syringa, Ligustrina amurense* t., *Buxus, Celtis, Vitis*, and at Wilczyn — *Azolla* and *Hydrocotyle ranunculoides* (pollen). Worth-mentioning is presence in the section (and in the two others), of a pollen of the family Hamamelidaceae (*Parrotia* t.), of *Hydrocotyle hirta* t. and *Lycopodium lucidulum* t. (K. Bińka, J. Nitychoruk, 1995).

FINAL REMARKS

Results of palaeobotanical analysis and found snail shells: *Viviparus diluvianus* (Kunth) and *Lithoglyphus jahni* (Urbanski) date carbonate deposition at the Mazovian Interglacial. Thus, the underlying till is of the San 2 Glaciation age and the other till, above the carbonate series, was formed at the end of the Odra or Warta? Glaciation (J. Nitychoruk, 1994). The palaeolake has existed, as indicated by a pollen diagram, since the end of the San 2 Glaciation until the beginning of the Odra or Warta? Glaciation. Origin of this lake is to be connected with disintegration of an ice sheet and melting-out of buried dead-ice blocks. Presence of the latter is proved by silts and clays at bottom of the carbonate series. The lake was the deepest and occupied the largest area during the Mazovian Interglacial. After a climatic optimum, the lake was considerably more shallow as proved by plant macrofossils in the section Wilczyn. Such shallowing was presumably due to a more continental climate and is recorded by supply with clayey material to the reservoir, particularly well indicated in the section Kaliłów and Wilczyn. Western part of the lake was probably deeper and wider than the eastern one. All the boreholes which have been palynologically analysed, prove that a most complete profile of lake sediments is preserved in the western part of the interglacial lake. To the east, there are only sediments of the initial part of the interglacial and of its optimum (K. Bińka, J. Nitychoruk, 1995).

Previous fieldworks indicate (J. Nitychoruk, 1994) that a couple of kilometres to the east and west of the described area, there are also sites with carbonate sediments of the same age. Therefore, continuation of a zone with meridional palaeolakes is to be expected. According to J. Nitychoruk (1994), continued occurrence of lakes along the same line, corresponding at satellitary photos to lineaments and sudden changes of fluvial pattern, can indicate tectonic influence. Except for a meridional tectonic orientation, there is also NE–SW one which corresponds to other systems of palaeolakes of the Mazovian Interglacial age and refers to bedrock tectonics (J. Nitychoruk, 1994).

Connection of the lake with tectonic structures was presumably reflected by deposition. Except for climatic changes, it could also influence a moving shoreline and resulting inflow of sands, gravels and tills (4a, b in Fig. 2). Similar inserts of sandy or clayey material within series of the Mazovian Interglacial are noted at the Mazury (Z. Borówko-Dłużakowa, W. Słowański, 1991) and the Siedlce Plateau (H. Winter, 1991).

Another problem, connected with sites of the Mazovian Interglacial sediments in the Podlasie, results from their covering with glacial series. A till, present in marginal parts of palaeolakes, forms a thin layer only and its thermoluminescence dating (160–180 ka) refers it to a younger glacial event rather i.e. to the Warta Glaciation. However, ice sheet extent during this glaciation is commonly accepted to have been more limited than during the preceding — the Odra Glaciation which occurred also after the Mazovian Interglacial. This problem still calls for further examination, particularly with petrographical methods.

CONCLUSIONS

1. Examined ancient lake sediments, composed of lake marl and gyttjas, are over 30 m thick and occur in a meridional depression (several kilometres long) to the northeast of Biała Podlaska.

2. Palaeobotanical analysis proved that the examined lake had existed since the end of the San 2 Glaciation, through the whole Mazovian Interglacial, until development of post-interglacial steppe grasslands; advance of ice sheet of the following Odra or Warta Glaciations occurred afterwards.

3. Basing on vegetation development, considerable shallowing of the lake just before and after the Mazovian Interglacial occurred. It was connected with a more continental climate and presumably with tectonic activity in lake zones.

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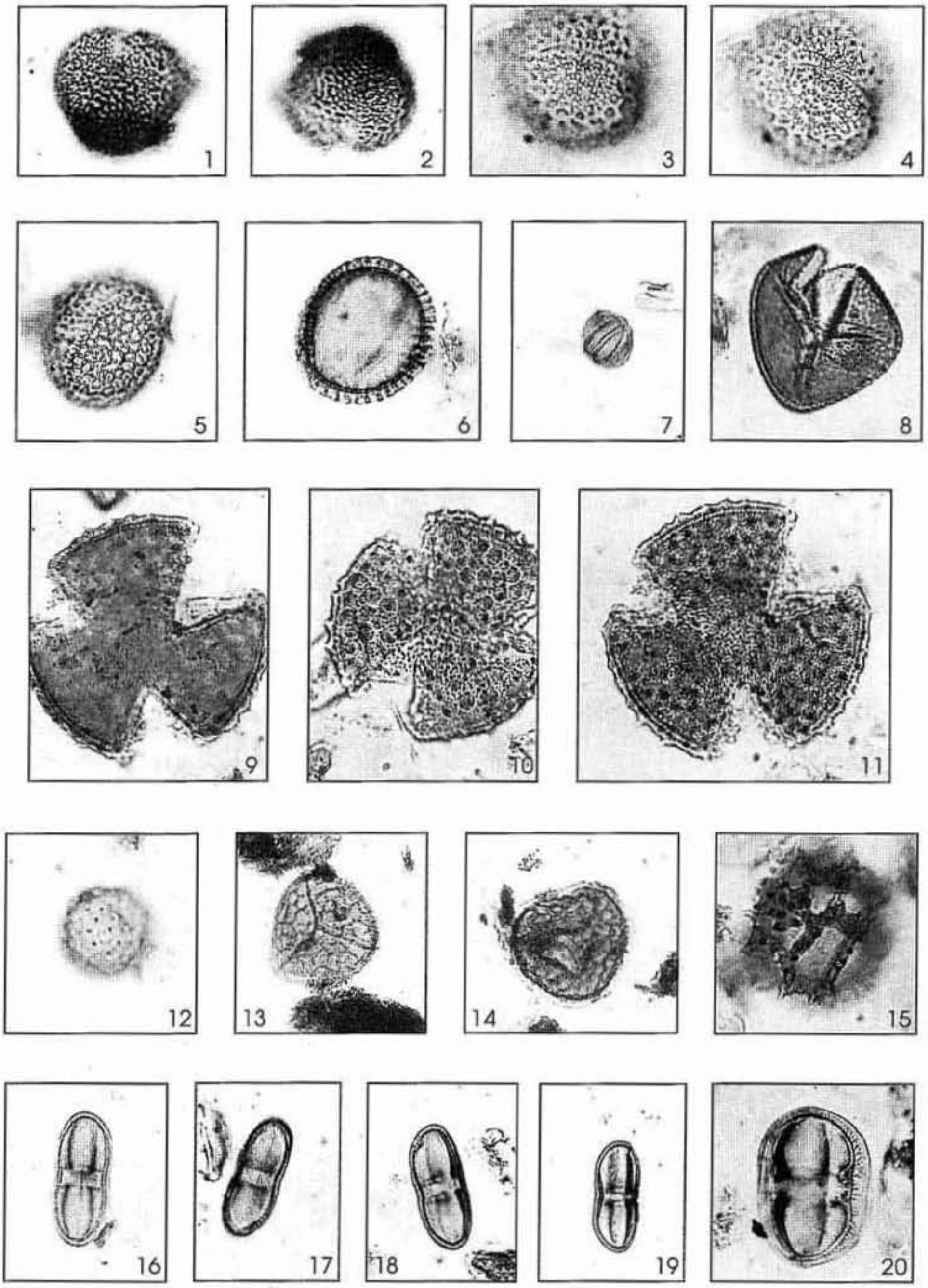
GEOLOGICZNE I PALEOBOTANICZNE BADANIA OSADÓW INTERGLACJALNYCH W KALIŁOWIE NA POŁUDNIOWYM PODLASIU

Streszczenie

W Kaliłowie k. Białej Podlaskiej stwierdzono osady jeziorne. Stanowią one pomost łączący dwa zbiorniki, uważane uprzednio za rozdzielone, w jeden zbiornik ciągnący się na przestrzeni kilkunastu kilometrów. Węglanowe osady zawierały zapis pyłkowy od okresu przedinterglacjalnej tundry (*Juniperus-Hippophaë*), poprzez poziom inicjalny interglacjału (*Pinus-Betula*), do faz zwiastujących poprawę warunków klimatycznych (*Picea-Alnus* i *Taxus*). W kolejnym poziomie — *Pinus-Larix* — dochodzi do krótkiego epizodu ochłodzenia wyrażonego zbiorowiskami nawiązującymi do stosunków panujących we współczesnej strefie borealnej (podpoziom **c**). Poziom optimum klimatycznego — *Carpinus-Abies* — cechuje się maksymalnym występowaniem ciepłolubnych drzew (jodły, grabu i dębu) oraz wskaźnikowych elementów ciepłolubnych — *Buxus*, *Vitis*, *Celtis*, *Parrotia* t. i *Viscum*. Okres pooptymalny został zaznaczony w dwóch poziomach: *Picea-Pinus-Pterocarya* i *Pinus-Juniperus*.

W czasie ich trwania następuje stopniowa eliminacja ciepłolubnych taksonów z wczesnych zbiorowisk oraz zwiększanie się udziału roślin światłolubnych — szczególnie jałowca i bylic. Charakterystyczne następstwo faz, a także udział licznych roślin wskaźnikowych pozwalają wiązać zbadane osady z interglacjałem mazowieckim.



Krzysztof BIŃKA, Jerzy NITYCHORUK — Geological and palaeobotanical setting of interglacial sediments at the Kaliłów site in southern Podlasie

PLATE I

Figs. 1, 2. *Ligustrum* t.
1 — columellae, 2 — muri
1 — widoczne kolumelle, 2 — widok na muri
Figs. 3, 4. *Ligustrina amurense* t.
3 — muri, 4 — columellae with multi-angular outline
3 — muri, 4 — kolumelle o zarysie wielokątnym
Figs. 5, 6. *Syringa* t.
5 — columellae with varying shapes, 6 — columellae, lateral view
5 — kolumelle o zmiennych kształtach, 6 — kolumelle widziane w położeniu bocznym
Fig. 7. *Mentha* t.
Fig. 8. *Selaginella helvetica*
Figs. 9, 11. *Valeriana tuberosa*
9 — echinae, transversal section, 11 — columellae zone
9 — widok na kolce w przekroju poprzecznym, 11 — strefa kolumelli
Fig. 10. *Valeriana* sp.
Fig. 12. *Xanthium* t.
Figs. 13, 14. *Riccia crystallina*
Fig. 15. *Sonchus arvensis* t.
Figs. 16–19. *Oenanthe* sp.
16, 17 — furrow and pore, 18, 19 — lateral view, noted are differences in development and thickness of nexine
16, 17 — widok na bruzdę i porę, 18, 19 — widok boczny, widoczne różnice w wykształceniu i grubości neksyny
Fig. 20. *Centaurea cyanus*