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Alicja BAŁUK, Kazimiera MAMAKOWA

Stratigraphic position of interglacial deposits at Przasnysz

Geological situation of the interglacial series of Przasnysz has been presented with reference to the nearby comprehensively described profiles. Basing on these profiles the stratigraphy of Pleistocene deposits has been determined according to the results of litho-petrographic, mineralogic and palaeontologic investigations as well as TL datings. The sequence has been subdivided into five major glacial units (including bipartite ones) and four interglacials. It has been proved that the interglacial deposits at Przasnysz refer to the second interglacial period (after Podlasie Interglacial which is defined as the oldest one). However the results of palaeobotanic analysis (by K.Mamakowa) revealed the pattern of vegetation parallel to Mazovian Interglacial (Holstein) succession. The latter is the fourth (last) of the presented interglacials. K.Mamakowa proposed an attempt to correlation of Przasnysz Interglacial with the IVth Interglacial of the Cromerian complex in Holland.

INTRODUCTION

The main purpose of geological research on Pleistocene at Przasnysz was the detailed recognition of the interglacial series described by W.Selle (1960). The author performed palynologic analyses of over ten samples of interglacial deposits and according to the results obtained, he suggested Mazovian age of the series (Mindel/Riss Interglacial). The profile described by W.Selle was 150.5 m thick and did not reach the Quaternary basement.

Opposite opinion on the age of this site was presented by S.Z.Różycki (1967) who correlated the interglacial series from Przasnysz with the oldest interglacial parallel to Cromerian. This approach excluded formerly defined Mazovian Interglacial at Maków Mazowiecki (M.Gołąbowa, 1957) from the discussion on its possible correla-

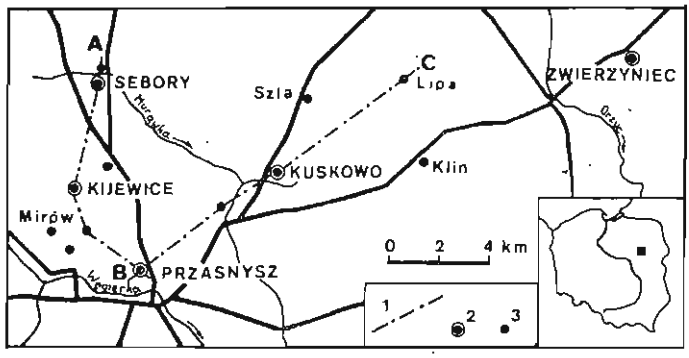

Fig. 1. Location sketch
1 – geological cross-section line; 2 – borehole; 3 – archival borehole
Szkic lokalizacyjny
1 – linie przekrojów geologicznych; 2 – otwory badawcze; 3 – otwory archiwalne

tion with Przasnysz series. However Przasnysz and Maków Mazowiecki are close each to other, their age identity was difficult to accept because of different type of pollen diagrams as well as uncomparable geological position of deposits. The series at Przasnysz is situated at 84–128 m below the surface and undoubtedly represents older Pleistocene member than outcropped sediments at Maków Mazowiecki.

During seventies five geological boreholes were drilled in the vicinity of Przasnysz (Fig. 1), and one of them was located at the site described by W.Selle (*lc.*). In all five boreholes the Quaternary substrate has been recorded at the depth of 170–258 m. All boreholes were cored that provided conditions for detail analyses of structure, texture, color, interlayer contacts of sediments etc. Core samples have been subjected to litho-petrographic and mineralogic investigations (J.Czerwonka, 1975; K.Kenig, 1977; J.Rzechowski et al., 1981), thermoluminescence analyses (J.Butrym, 1982) palynologic investigations (Z.Dłużakowa, 1975, 1979; Z.Janczyk-Kopikowa, 1982; L.Stuchlik, 1975) and malacologic research (S.Skompski, 1983). A comprehensive palaeobotanic study on interglacial deposits from Przasnysz borehole has been presented by K.Mamakowa (1983).

All considerations on the stratigraphy of Pleistocene in the Przasnysz area began with lithofacies analyse of each profile based on core and laboratory investigations. All results were compared with archival records regardless their new genetic and age classification. The lithostratigraphic correlation of described series allowed to situate the interglacial of Przasnysz within the South-Polish Glaciations suite between Nida and San stages (A.Bałuk, 1982, 1983). Since it does not correspond neither with the "oldest interglacial" nor with the Mazovian.

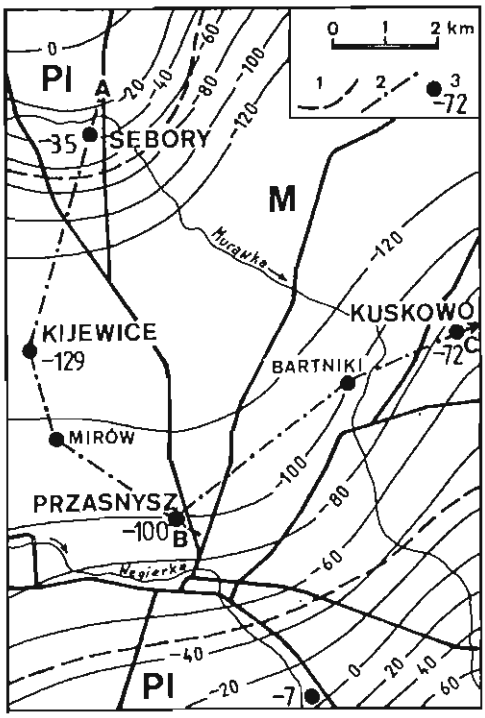

Fig. 2. Geological sketch of Quaternary substrate in the vicinities of Przasnysz (isohypses every 20 m)

1 – geological boundary; 2 – geological cross-section line; 3 – borehole with absolute height of Quaternary substrate in meters above sea level; M – Miocene; Pl – Pliocene

Szkic geologiczny podłoża czwartorzędu w okolicach Przasnysza (izohipsy co 20 m)

1 – granice geologiczne; 2 – linie przekrojów geologicznych; 3 – otwory z wysokością bezwzględną spągu czwartorzędu; M – miocen; Pl – pliocen

REMARKS ON THE QUATERNARY SUBSTRATE

At Przasnysz the above mentioned considerable thickness of the Quaternary cover is related to a deep depression of the Tertiary basement (Fig. 2). Due to results of drillings at Kijewice and Przasnysz its bottom is situated 129 and 100 m below sea level respectively. It is few kilometers wide and separates two broad regions of highly elevated Tertiary. The depression extends to the west, and to the east it joins a wide sub-Quaternary depression of the Lower Narew drainage basin (A.Bałuk 1989, 1991).

According to the profiles presented in this paper (except of the Sebory profile), the Quaternary substrate contains undisturbed horizontally bedded Miocene sands. Pliocene variegated clays were found derectly under Quaternary deposits at Sebory only, and their contact with the oldest till is of glaciotectonical character.

STRATIGRAPHY AND LITHOFACIES ANALYSIS OF PLEISTOCENE DEPOSITS

Within the basement depression at Przasnysz both glacial and intermorainic Quaternary series are developed quite good. Hence the described area is predesti-

nated for investigations on Pleistocene stratigraphy and the findings approach to the relatively comprehensive stratigraphic synthesis.

Much of attention was paid to tills. Their quantitative features were analysed on the background of their position in the profile. To determine warmer periods thick fluvial series were taken into account in common with biostratigraphic data. The occurrence of thick fluvial series is related to the tendency of regeneration of river valleys in succeeding interglacials.

In the Przasnysz area the Pleistocene sequence is composed of at least five major glacial units which represent Narew, South-Polish (Nida, San, Wilga) and Middle-Polish glaciations subdivided with the following four interglacials: Podlasie (Kijewice), Przasnysz, Kurpie (Ferdynandów) and Mazovian.

NAREW GLACIATIONS

The oldest glacial complex recorded in sub-Quaternary depression at Przasnysz is about 70 m thick, and its top amounts 20–30 m below sea level (Fig. 3–5). S.Z.Różycki (1978, 1980) has subdivided Narew Glaciation in two stadials (Narew I and Narew II) which are recently given a rank of separate glaciations[1]. It is probable that both glaciations are represented in the Przasnysz area and the younger one is bipartite.

The Early Pleistocene complex at Przasnysz begins with till (20 m) overlain with a clay layer (7 m) of greenish-grey-brown-white color with diversified slump structures (Fig. 3). Some evidences of weathering were observed in the top of till and clays (J.Rzechowski et al., 1981).

Calcareous clays which built the lower part (30 m) of the Kuskowo profile are comparable to Przasnysz clays. There are thin layers of compressed peat abundant in *Alnus* pollen in their bottom (Z.Dłużakowa, 1979). Many-coloured lacustrine clays gradually pass upwards in ice-dam clays, which in turn become varved and glaciotectonically deformed in the top. The clay horizon probably represents a warm period of interglacial rank.

Above the lacustrine series the second till layer (7.4 m) with small intercalations of clays of that series has been recorded at Przasnysz. It is separated from the third till with a 2.5 m thick layer of grey, calcareous silt with humic spots and few small plant remnants. The till of the third horizon (31 m) contains also small intercalations of many-coloured clays. The top of the till layer is formed as a well developed boulder pavement.

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[1] General stratigraphic subdivision of Quaternary for the purpose of the *Detailed Geological Map of Poland* in the scale of 1:50 000. PIG, 1990

High content of local rocks' gravels is a common feature of tills in this complex (Paleogene siltstones — 16–18% on an average, Cretaceous marls and limestones — 5–7% on an average). Among Scandinavian gravels crystalline fragments prevail in general thus the average values of petrographic coefficients (O/K – K/W – A/B)[2] are similar each to other (Fig. 3). Also heavy minerals' content is generally equal (about 30% on an average) epidotes content is typically high (about 10%) and pyroxenes are relatively numerous (about 4%). This assemblage indicates mineralogic relationship with the Scandinavian alimentary area.

At Kuskowo the till overlying the clay series contains also more crystalline than Scandinavian limestone gravels. The admixture of local gravels (siltstones) is extremely high there (max. 40%, average 23%). The content of heavy minerals reflects the local basement as well. Garnets content (47.5%) is over twice as high as amphiboles content (20%). Zircons and disthenes (redeposited from Miocene) are considerably numerous (8.6 and 5.3% respectively).

At Sebory an individual layer of till of the same age (13 m thick) has been separated from the thick till complex due to petrographic investigations. Concerning the compound of gravels it is a very uniform till and its petrographic coefficients are similar to Kuskowo ones. Local gravels are not as abundant as at Kuskowo and Przasnysz (siltstones – 7%, limestones – 6.6%, sandstones – 5.7%). Concerning mineralogic features the till described is similar both to Kuskowo and to local Neogene deposits (garnets – 41%, amphiboles – 23.5%, zircons – 7.4%, disthenes – 6.3%, staurolites – 4.6%).

It is proved that there is a direct relationship between the lithology of tills and the lithology of the Quaternary substrate, especially if the oldest glaciation is considered (J.Rzechowski, 1982). The present data confirm the principle. The lower till horizon of Przasnysz (located below clays) represents the older glacial unit within the Narew Glaciation (N-I). The younger unit (N-II) is represented by tills from Kuskowo and Sebory and probably by two upper horizons from Przasnysz, which are found above lacustrine clays and contain their intercalations.

PODLASIE (KIJEWICE) INTERGLACIAL

The Narew Glaciation deposits are not recorded at Kijewice. Directly on Miocene deposits (129 m b.s.l.) there is a 58 m thick fluvio-lacustrine series there, which represents early Pleistocene river valley accumulations. No less deep situated fluvial deposits of big thickness are reported from adjacent territories. Their occurrence is related to well developed river system of the oldest interglacial and to far advanced processes of erosion and accumulation (A.Bałuk, 1991).

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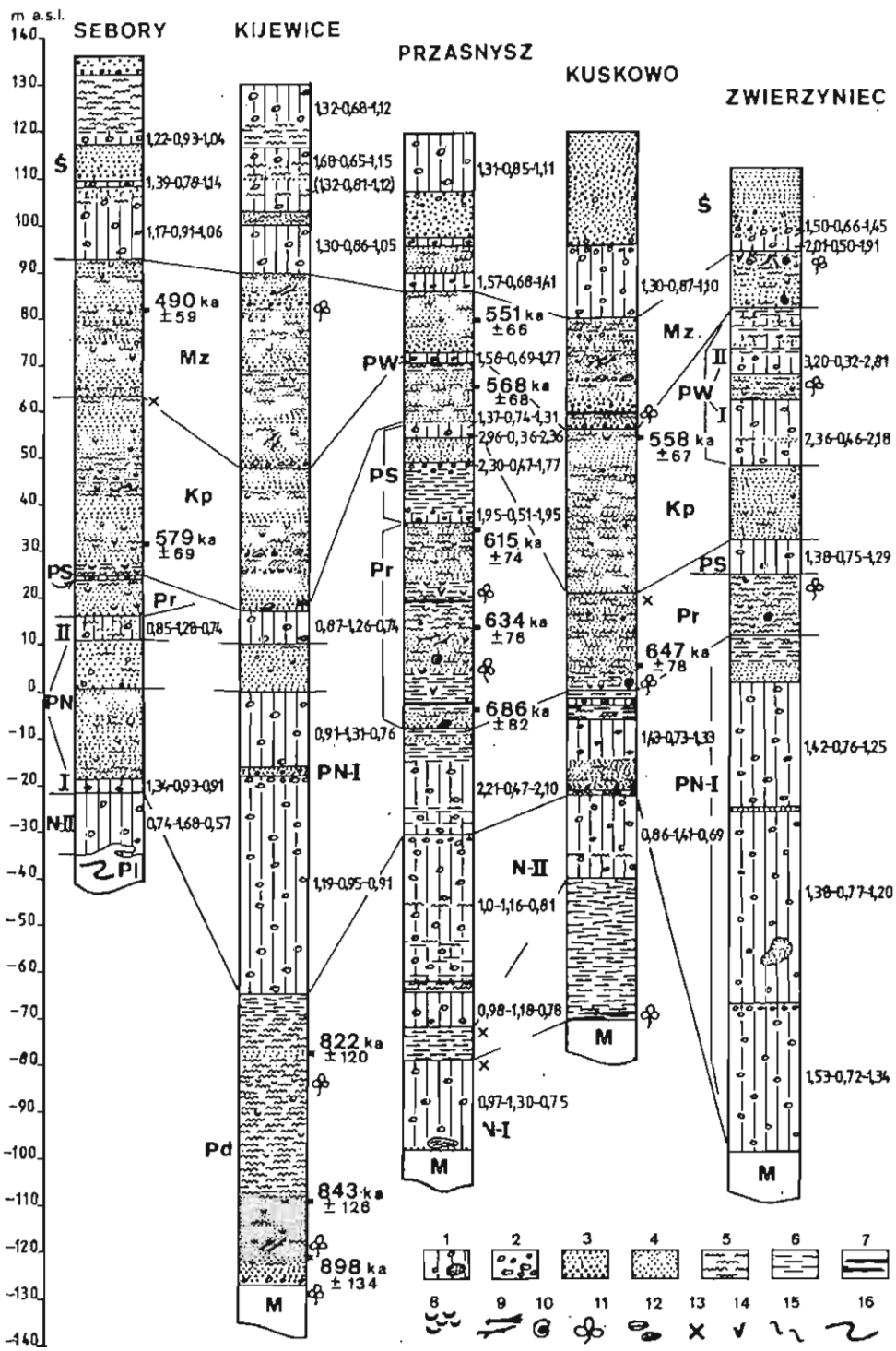
[2] Petrographic coefficients are calculated as the ratios of different Scandinavian rocks basing on the content of gravels of 5–10 mm diameter extracted from the till. Explanation of symbols: O – sedimentary rocks, K – crystalline rocks and quartz, W – calcareous rocks, A – rocks not resistant to weathering, B – rocks resistant to weathering


m a.s.l.
SEBORY
KIJEWICE
PRZASNYSZ
KUSKOWO
ZWIERZYNIEC
Ś
Mz
Kp
Pr
PS
PW
PN
I
II
N-II
N-I
Pl
Pd
M
490 ka ±59
579 ka ±69
822 ka ±120
843 ka ±126
898 ka ±134
551 ka ±66
568 ka ±68
634 ka ±76
686 ka ±82
615 ka ±74
558 ka ±67
647 ka ±78
1,22-0,93-1,04
1,39-0,78-1,14
1,17-0,91-1,06
1,34-0,93-0,91
0,74-1,68-0,57
1,32-0,68-1,12
1,68-0,65-1,15
(1,32-0,81-1,12)
1,30-0,86-1,05
0,87-1,26-0,74
0,91-1,31-0,76
1,19-0,95-0,91
1,31-0,85-1,11
1,57-0,68-1,41
1,58-0,69-1,27
1,37-0,74-1,31
2,96-0,36-2,36
2,30-0,47-1,77
1,95-0,51-1,95
2,21-0,47-2,10
1,0-1,16-0,81
0,98-1,18-0,78
0,97-1,30-0,75
1,30-0,87-1,10
1,63-0,73-1,39
0,86-1,41-0,69
1,50-0,66-1,45
2,01-0,50-1,91
3,20-0,32-2,81
2,36-0,46-2,18
1,38-0,75-1,29
1,42-0,76-1,25
1,38-0,77-1,20
1,53-0,72-1,34
1 2 3 4 5 6 7
8 9 10 11 12 13 14 15 16

The series of Kijewice begins with coarse grain sands (6.5 m thick) containing Scandinavian material among gravels and bottom pebbles. Generally the sands are not good graded, silty in places and with slightly decomposed wood fragments. Heavy minerals assemblage is typical of Pleistocene (abundance of tourmalines, garnets, biotite and amphiboles).

The deposits were accumulated by strong water currents. Upwards they pass into fine, cross laminated sandy sediments accreted under weak water current conditions. Organic matter admixture including wood particles is pretty considerable. The sands are moderately graded, and quartz grains are very good rounded. $CaCO_3$ content is 1.2–3.5%. The bottom and the top of the sequence have been dated at 898±134 ka BP (Lub 997) and 843±126 ka BP (Lub 996) respectively (TL method).

Above there are pelitic lacustrine deposits about 40 m thick. They are light, with high mica content, not bedded but with slightly visible slump structures. The age of their upper part has been determinated by TL method at 822±120 ka BP (Lub 995).

Palynologic expertise of described deposits (12 samples) and of their Tertiary sandy basement (4 samples) have been performed by L.Stuchlik (1975). He found no correlation with the older Quaternary pollen diagrams and thus described the age of all analysed deposits as older than Pliocene and not older than the Upper Miocene, according to the high content of Tertiary plant representatives.

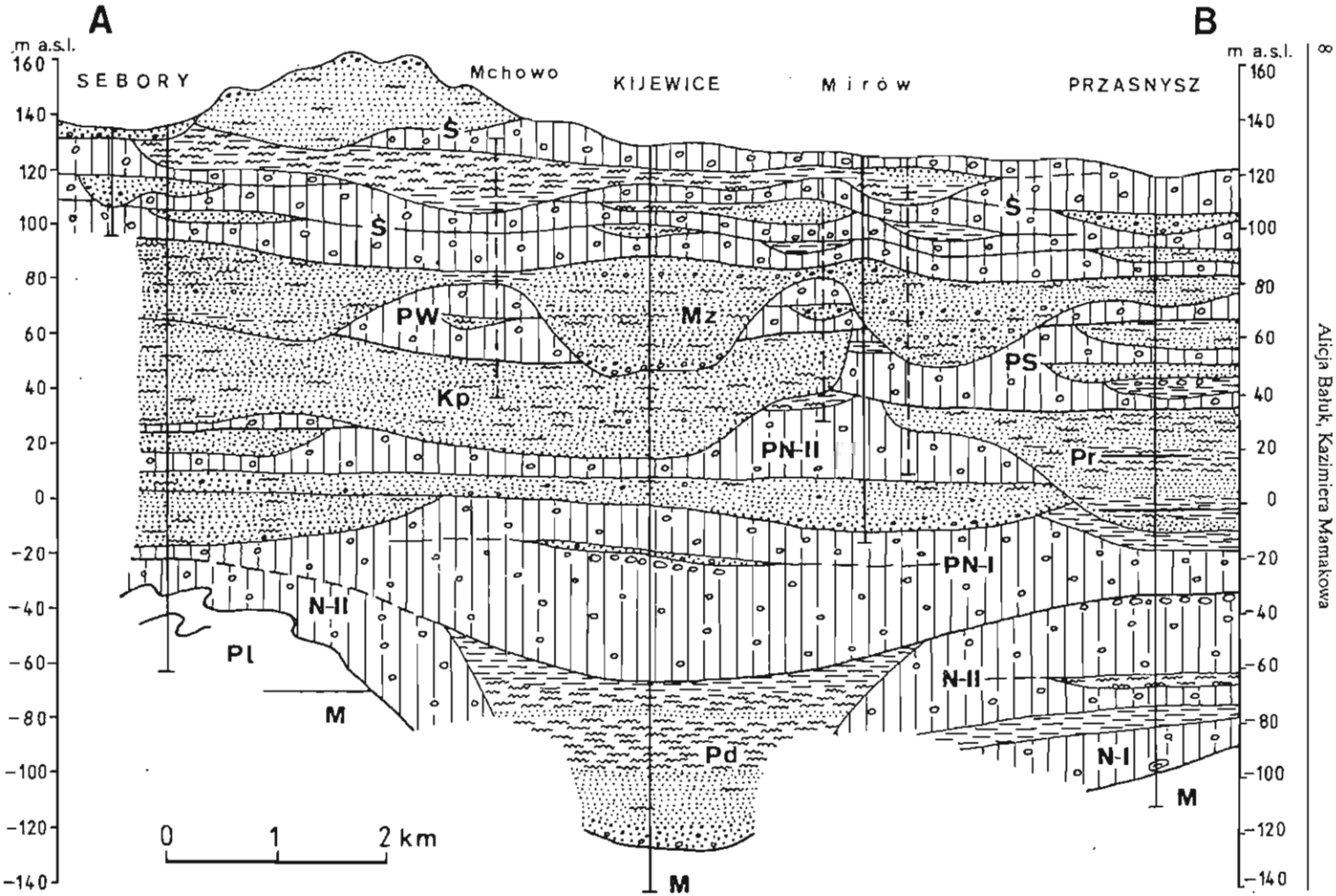
However the result of analysis is due to redeposition of pollen from the Upper Miocene basement which has been deeply eroded by an early Pleistocene river valley (Fig. 4). The series of Kijewice does not differ from other Quaternary fluvio-limnic series in the lithofacies character. Following the pollen diagram, old Pleistocene deposits contain less Tertiary taxons than the basement sediments. Tertiary pollen and Quaternary AP representatives (*Betula*, *Alnus*, *Quercus* as well as *Fagus*, *Picea*,

Fig.3. Pleistocene profiles recorded in boreholes at Przasnysz

1 – till (in places with floes of older sediments); 2 – pebbles and gravel; 3 – coarse and medium-grained sand; 4 – fine and very fine sand; 5 – silt, dust; 6 – clay; 7 – peat, peaty mud; 8 – plant detritus, humus accretions; 9 – wood fragments; 10 – mollusc shells remnants; 11 – palynologically analysed deposits; 12 – clay ball; 13 – wethered horizon; 14 – vivianite; 15 – glauconite; 16 – glaciotectonic deformations; petrographic coefficients O/K – K/W – A/B and TL datings are given on the left side of the profiles; the following stratigraphic symbols are given on the right side of the profiles: N – Narew Glaciations, Pd – Podlasie Interglacial, PN – Nida Glaciation, Pr – Przasnysz Interglacial, PS – San Glaciation, Kp – Kurpie Interglacial, PW – Wilga Glaciation, Mz – Mazovian Interglacial, Ś – Middle-Polish Glaciation; stratigraphic symbols of the sub-Quaternary basement – see Fig. 2

Profile plejstocenu w otworach badawczych koło Przasnysza

1 – glina zwałowa (miejscami z porwakami osadów starszych); 2 – otoczaki i żwir; 3 – piasek grubo- i średnioziarnisty; 4 – piasek drobno- i bardzo drobnoziarnisty; 5 – mułek, pył; 6 – ił; 7 – torf, namuł torfiasty; 8 – detrytus roślinny, nagromadzenia humusu; 9 – fragmenty drewna; 10 – szczątki skorupek mięczaków; 11 – osady badane palinologicznie; 12 – toczeńce iłu; 13 – poziom wietrzeniowy; 14 – wiwianit; 15 – glaukonit; 16 – zaburzenia glacitektoniczne; z lewej strony profilów podano wartości współczynników petrograficznych O/K – K/W – A/B oraz wyniki datowań TL, z prawej – następujące oznaczenia stratygraficzne: N – zlodowacenia narwi, Pd – interglacjał podlaski, PN – zlodowacenie nidy, Pr – interglacjał przasnyski, PS – zlodowacenie sanu, Kp – interglacjał kurpiowski, PW – zlodowacenie wilgi, Mz – interglacjał mazowiecki, Ś – zlodowacenie środkowopolskie; symbole stratygraficzne utworów podłoża czwartorzędu jak dla fig. 2


A
B
m a.s.l.
160
140
120
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80
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40
20
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-20
-40
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SEBORY
Mchowo
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Kp
PS
PN-II
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Ulmus) content are usually equal there (23% on an average) while in Miocene samples they are 33 and 17% respectively. *Pinus* prevails in all samples examined.

The fluvio-lacustrine series of Kijewice is by 4-m thick layer of ice-dammed clays with glaciotectonic deformations. These clays represents the following period of lacustrine sedimentation during the beginning of the South-Polish Glaciations cycle.

SOUTH -POLISH GLACIATIONS

N i d a G l a c i a t i o n . In the vicinities of Przasnysz this stage forms thick, composed and lithologically diversified complex. It fulfills a sub-Quaternary depression up to 30-40 m above sea level. It consists of at least two individual glacial units. The older one (PN-I) is supposed to be found in all profiles described.

At Kijewice, the till of the older substage (67–2 m b.s.l.) is subdivided by sandy--gravel intercalations and scour casts. Average value of petrographic coefficients O/K and A/B is usually low. Upwards the crystalline gravels gradually increase their prevail on the Palaeozoic limestone gravels. Sandstone gravels predominate among local rocks (10% on an average in the lower part, 18% on an average in the upper part). Among heavy minerals, garnets (30% on an average) prevail on amphiboles (17 and 20%). Zircons (19 and 13%), tourmalines (12% on an average) and epidotes (10% on an average) contents are high. This compound is probably due to supply of old Tertiary material to the entire morainic series.

In a three-part till complex from Zwierzyniec (101–0.5 m b.s.l.) which is correlable with above series, Paleozoic limestones constantly, though slightly, prevail on crystalline gravels. However local rocks assemblage comprises mainly sandstones (14–16% on an average), like at Kijewice. Petrographic coefficients are similar each to other throughout all three parts of the glacial complex of Zwierzyniec (Fig. 3). Mutual relationship of tills is also expressed by heavy minerals' assemblage compound which is parallel to Kijewice. The influence of the local Paleogenic basement is also evidenced by Oligocene sands incorporated into Quaternary sequence.

The upper till of Zwierzyniec is correlable with the series of fluvioglacial, morainic and ice-dam deposits at Kuskowo (the same height interval of 23–2 m b.s.l.). It is confirmed by the composition of Scandinavian gravels. Petrographic coefficients calculated for Kuskowo till (8 m thick) almost do not differ from Zwierzyniec till. However the local gravels' material (siltstones, 10% on an average) and heavy minerals assemblage (garnets — 46%, amphiboles — 23%, zircons — 5,4%, disthenes, tourmalines and staurolites — 3% each, lack of glauconite) indicate influence of

Fig. 4. Geological eross-section A – B
Explanations — see Fig. 3
Przekrój geologiczny A – B
Objaśnienia jak dla fig. 3

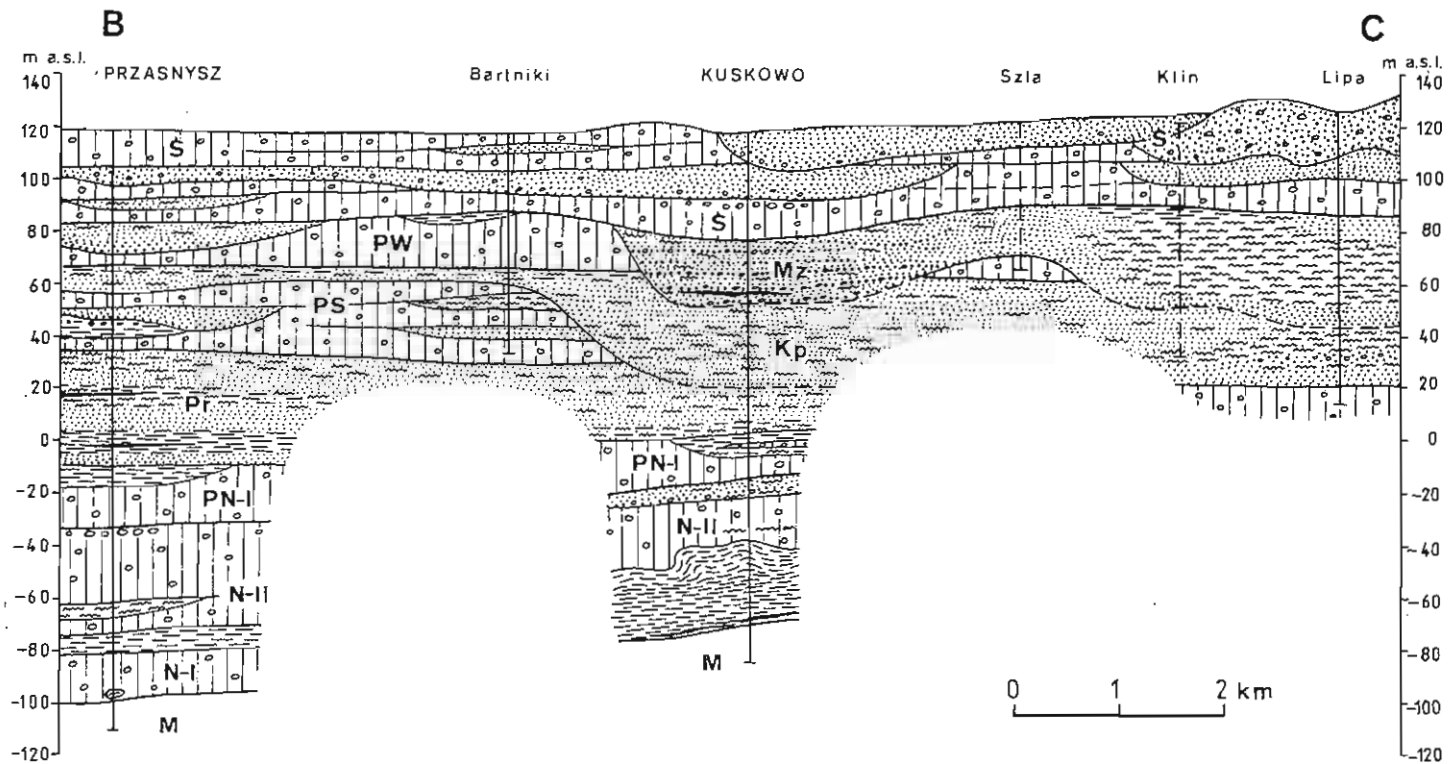


Fig. 5. Geological cross-section B – C
Explanations — see Fig. 3
Przekrój geologiczny B – C
Objaśnienia jak dla fig. 3

young Tertiary basement lasting from Narew Glaciation. This influence is encountered at Sebory as well. There the till layer (about 22–19 m b.s.l.), which is recognized the same age as above described ones, resembles Kuskowo till as far as mineralogic features and local gravels' content is concerned (siltstones about 29%). Petrographic composition of Scandinavian gravels is in turn parallel to neighbouring profile at Kijewice (lower part of the section).

Over the Narew complex at Przasnysz (33–17 m b.s.l.) there is a till with clay intercalations which gradually passes upwards into grey and reddish clays (7 m). Both in tills and clays heavy minerals' assemblage composition is generally equal. However it is similar to tills of Narew Glaciation (in the same profile). Thus the lithologic relationship of glacial deposits with Scandinavian alimentation area is evidenced again. Local substrate influence is not expressed there, as the local gravels are scarce (sandstones — 4.6%, siltstones — 2.7%). Among the Scandinavian particles the limestone gravels are much more abundant than crystalline ones, thus the O/K and A/B coefficients are high and considerably differ from the Narew morainic series.

Both glacial units of Nida Glaciation are divided by fluvial and fluvioglacial deposits. The former are known from Sebory (19 m b.s.l.–1 m a.s.l.) as multicycle sandy series. In places they contain humus and charred plant remnants. Variable roundness of quartz grains is probably caused by changeable sedimentary processes under moderately cool or periglacial climatic conditions (J.Rzechowski et al., 1981). The top of the fluvial series is built of well developed fluvioglacial sands (about 0–10 m a.s.l.) known from Sebory and Kijewice (Fig. 4).

The succeeding ice sheet advance (PN-II) resulted in till layer found at the same level in both profiles described (about 10–15 m a.s.l.). According to equally low values of petrographic coefficients O/K and A/B and to high content of local gravels (siltstones — about 20%, flints up to 12%) the position of this horizon at Kijewice and Sebory has been determined precisely.

P r z a s n y s z I n t e r g l a c i a ł (M a ł o p o l a n i a n). At Przasnysz the interglacial deposits (10 m b.s.l.–34 m a.s.l.) are composed of several sequences which reflect several cyclic sedimentary changes. Their contacts are of graded character. Only the lowermost fluvial sands (about 3 m thick) which are incised in grey and reddish clays of Narew Glaciation have distinct top and bottom surfaces. Charred plant remnants and black mud balls armoured with mollusc shells are found at the bottom of the sands.

Dark grey, dense clays (10 m thick) which occur above, are limeless, structureless, enriched in humus and contain a thin layer of peat (0.3 m thick) in the bottom part. Peat and vivianite (found in clays) indicate lacustrine to bog environment which is typical of abandonned channels and bogs of flood plaines. These deposits are correlated with the warmest interglacial period by K.Mamakowa (pollen assemblage zones P-1, P-2, P-3). Its beginning is dated by TL method at 686±22 ka BP (Lu 138).

Climatic optimum comprises the bottom part of the succeeding member (9 m thick). It is formed of fluvial sands with abundant plant detritus, wood fragments and

mollusc remnants. The top of the sands has been dated by TL method at 634± 76 ka BP (Lu 137).Upwards they pass into the second lacustrine-bog sequence (10 m thick) composed generally of silts and clays with humus, vivianite and peat intercalations (pollen assemblage zones P-4 and P-5).The interglacial series[3] is completed with sandy-silty unit (about 12 m thick).It was accumulated under cooler climate conditions by weak or seasonal water flow (pollen zone P-5). The end of this stage is limited by TL date of 615±74 ka BP (Lu 136).

At Kuskowo in the lower part of intermorainic series (about 2 m b.s.l.–18 m a.s.l.) an age of 647±78 ka BP (Lu 141) has been obtained owing to the TL datings. This result makes it possible to correlate it with interglacial deposits at Przasnysz. Actually Przasnysz Interglacial is correlated with fine sandy-silty fluvio-lacustrine deposits with constant admixture of plant detritus at Kuskowo. In their bottom there are clayey silts with mollusc remnants and redeposited pollen. The pollen assemblage is composed mainly of Tertiary and older sphoromorphs (Z.Janczyk-Kopikowa, 1982). The upper limit of described deposits is defined by erosional surface and soil horizon below.

The same stratigraphic position is attributed to fluvial sands of one depositional cycle at Sebory (16–23 m a.s.l.)which are weakly calcareous and contain pretty good rounded quartz grains and humus intercalations.

Also lacustrine-bog deposits of Zwierzyniec (9.5–22.3 m a.s.l.) are probably parallel to Przasnysz Interglacial. Their appearence is connected with an ice-dammed basin which was formed during Nida Glaciation and caused the origin of mostly red deposits. Above there are silts with considerable humus admixture, plant remnants and mollusc shells. Palynologic expertise of two samples derived from the upper part of silts revealed the occurrence of *Pinus sylvestris* (28 and 31%), *Alnus* and *Picea* (up to 8%), *Betula* and *Corylus* (up to 5%), *Ulmus* and *Carpinus* (about 1% each) and herb pollen (Z.Dłużakowa, 1975).

San Glaciation. This stage is supposed to be relevant to South-Polish Glaciation (J.E. Mojski, 1985) or to South-Polish Glaciation *sensu stricto* (within the suite of glaciations of this name). According to this approach, San Glaciation is subdivided into two stadials ((J.Rzechowski, 1986; M.D.Baraniecka, 1990).

In described area the deposits of San Glaciation have been considerably removed due to erosion. They have been found at Przasnysz and Zwierzyniec only because at Sebory they are mercly represented by residual layer of till situated about 24 m a.s.l. (Fig. 3, 4).

Above the interglacial series at Przasnysz (34.5 m a.s.l.) there is a 1 m thick till, which passes gradually upward into grey and red clays (12 m thick) with accretions of gravels and pebble in the top. Its is overlain by a sandy bed (5.3 m thick) representing one alluvial cycle and by residual morainic horizon (52.5–55.7 m a.s.l.). The latter

[3] In the light of paleobotanic research the pollen assemblage zone P-5 is related to the glacial period; see page 21.

belongs to San Glaciation as well. Laboratory investigations were not appropriate there as the tills were poorly represented. Single samples of gravels from the lower till and from the top of clays revealed considerable prevail of Palaeozoic limestones on crystalline rocks thus the values of petrographic coefficients (O/K and A/B) are high. They are even higher (2.96–0.36–2.36) in the bottom part of the upper till but decrease in value at the top (1.37–0.74–1.31) according to the decrease of limestones' content. Among gravels local rocks are represented mainly by Tertiary siltstones (4–6%) which are extremely numerous at the top of clays (11%).

At Zwierzyniec the till found at the depth of 22.3–30 m a.s.l. was assigned to the San Glaciation. It is equally enriched in Scandinavian limestones and crystalline gravels (about 50 and 40% respectively). There the petrographic coefficients have almost the same values as of the top till at Przasnysz (1.38–0.75–1.29). They are also very similar to the coefficients known from the lower part of Zwierzyniec profile (Nida Glaciation). However the till of San Glaciation considerably differs in the low content of Tertiary gravels (about 3%, mainly sandstones) from the older morainic complex.

The heavy minerals composition reflects the weakened influence of the local basement as well. In comparison with the older tills at Przasnysz and Zwierzyniec, San tills are enriched in amphiboles and reduced in local basement-derived particles (zircons, tourmalines).

Kurpie Interglacial (Ferdynandów). In the lower Narew drainage basin this stratigraphic unit has been recognized between glacial stages of San and Wilga (A.Bałuk, 1991). This stratigraphic position is assigned to the deposits of fluvial and fluvio-lacustrine origin. They are found in several profiles due to well developed valley system of this period.

In the vicinities of Przasnysz the top surface of interglacial deposits is of erosional character in some places. At Sebory and Kijewice they are found in the lower part of fluvial series (about 70 m thick). In the Sebory profile the Kurpie Interglacial deposits have been recognized immediately below the soil horizon (about 63 m a.s.l.) basing on TL datings. The deposits are lithofacially diversified there and comprise different sediments — from channel sands of different grain seize to flood muds with humus and plants' remnants (TL date of 579±69 ka BP; Lu 143). They form 5 sedimentary cycles about 38 m thick totally. Quartz grains are usually good and in places very good rounded there. This probably resulted from the accumulation under temperate climate conditions (J.Rzechowski, et al., 1981). The deposits are non calcareous ($CaCO_3$ content is generally 1–2%). Particles which are resistant to mechanical weatherig prevail among the heavy minerals there (garnets, zircons, dysthenes).

At Kijewice the same age has been assigned to the lower part of sandy series located below the distinctly visible erosional surface (about 47 m a.s.l.). The sedimentation had a cyclic character there, too, as 5 sedimentary sequences have been described (32 m of total thickness). Contrary to Sebory the deposits of flood plains are

merely represented there, quartz roundness is worse and $CaCO_3$ content is quite equal throughout the series (about 3–4%).

Fine sandy-silty deposits from Przasnysz which are correlated with the above described ones (56–67 m a.s.l.) have been dated by TL method at 568±68 ka BP (Lu 135). They probably refer to San recession because their contact with underlying till of the same glaciation is not sharp and reflects some continuation of sedimentary process. Quartz grains' roundness is good only in the upper part of this suite, and garnets are abundant there. That allows to identify fluvial sedimentation under moderately cool climate conditions.

At Kuskowo alike to Sebory and Przasnysz, the middle section of fluvio-lacustrine deposits have been dated by TL method at 558±67 ka BP (Lu 140). Beginning with 18 m a.s.l. up to the distinct erosional surface at 54.5 m a.s.l. there are fine-grained and silty sands as well as silts with gradual contacts between there. They were deposited due to low-energy sedimentation as ripplemarks are common, some layers are horizontally laminated and muscovite, biotite and chlorite are abundant there. $CaCO_3$ content is controlled by grain size. It amounts 4–6% in silts but decreases in sands 1–2%). Throughout the series organic matter and plants' detritus are abundant.

The Kurpie Interglacial sediments have been found at Zwierzyniec, too (31–46 m a.s.l.). Sands with humus and glauconite admixture are located there between tills of San and Wilga glaciations. The heavy minerals assemblage does not reveal any relationships with these tills. It is probably connected with washing out the local Tertiary deposits.

W i l g a G l a c i a t i o n . Its morainic horizon is most fragmentary preserved from any other described before. It has been reduced by extremely intense Mazovian erosion.

Only the lowermost part of Wilga Glaciation deposits has been preserved at Przasnysz (67–71 m a.s.l.). It is composed of silt layer and thin (1.7 m) till horizon of mud flow character. The till is reduced in gravels and has an anomalous high Paleogene siltstones' content (about 33%). Abundant amphiboles (about 35%) and piroxenes (10%) and relatively low content of garnets (24%) are typical of it. In the nearby profiles (Mchowo, Bartniki, Fig. 4, 5) the till horizon has not been removed and forms a bipartite series of 20–30 m thick tills.

The most developed complex of Wilga Glaciation deposits is found at Zwierzyniec (46–80 m a.s.l.). It is composed of tills which are separated by warm period deposits and belong to two glacial units (PW-1 and PW-2).High values of petrographic coefficients O/K and A/B in consequence of high content of Scandinavian limestones' gravels are the common feature of these tills. But they differ each from other in local gravels' content. The older till contains 10% of sandstones' gravels on an average and the younger one only 2.3%. The heavy minerals' compound is similar to other tills of this profile because of continuous influence of Paleogene deposits. Major components are garnets (32 and 28% on an average in the older and younger

till respectively), amphiboles (19 and 15%), epidotes (17 and 16%), tourmalines (11 and 13%) as well as zircons which are extremely abundant in the younger till (8 and 20%). The younger till has a subglacial character (basal till) only within the lower part (4 m). Immediately above there is a flow till composed of intercalated tills, clays, silts and sands of indistinct limits (10 m).

At Zwierzyniec the glacial units are divided by a sandy silt layer (6 m thick) enriched in humus. Most probably they were accumulated in a lake basin during the warm period. According to the palynologic expertise, coniferous forests prevailed. There were mostly pine forests with the spruce and fir admixture and with the small share of the deciduous trees — birch and alder (Z.Dłużakowa, 1975).

MAZOVIAN INTERGLACIAL

At Zwierzyniec, above the flow till of Wilga decline there is a sandy-silty series with admixture of humus which increases upwards and with mollusc remnants (80–92 m a.s.l.). At the top part the accretion of plants' remnants, wood fragments and mollusc shells is so plentiful that in some places it resembles an organic breccia or a shelly conglomerate. Vivianite was found there, too. Z.Dłużakowa (1975) recognized an interglacial type of the deposits due to palaeobotanic analyses and suggested their Mazovian age.

Following the pollen diagram three phytophases have been described above the pine-birch forest phase. The first one represents pine (*Pinus*) forests with spruce (*Picea*) and fir (*Abies*). In the second phase deciduous trees appeared (*Betula, Alnus, Quercus*) and herbaceous plants started to occur. In the third phase pine forests began to be replaced by mixed spruce-fir (*Picea-Abies*) forests with alder (*Alnus*), elm (*Ulmus*), oak (*Quercus*), linden (*Tilia*), hornbeam (*Carpinus*), yew (*Taxus*) and hazel (*Corylus*). Moreover in the deposits representing the first and the second phytophase microsporangia of *Salvinia* have been recorded. Usually the occurrence of *Salvinia* is connected with climatic optimums of interglacials.

Relatively univocal results of malacologic research confirmed the Mazovian age of deposits from Zwierzyniec. S.Skompski (1983) described an abundant assemblage of fresh-water mollusc there. *Litoglyphus jahni* and *Viviparus diluvianus* specimens which became extinct at the end of Mazovian Interglacial have been found there, too. Thus the described deposits cannot belong to the younger period. Their stratigraphic position does not indicate the older age neither. Concerning the hypsometric position they are situated comparably to the Mazovian Interglacial deposits at Maków Mazowiecki, about 30 km to the south (M.Gołąbowa, 1957).

In the vicinities of Przasnysz the Mazovian Interglacial is very clearly expressed by well developed fluvial series (Fig. 4, 5). They fulfil a deep erosional pattern which in places is incised in the deposits of Kurpie Interglacial. The entire area is supposed to provide favourable conditions to recurrence of the river system in the following interglacials. The top of the Mazovian Interglacial alluvia reaches 80–90 m a.s.l. (Fig.

3). The occurrence of 5–6 well preserved sedimentary sequences (Sebory, Kijewice, Kuskowo) indicates the effects of accumulation in a mature, probably meandering river. Lateral accretions are most distinctly expressed at Kuskowo (silts, clays, muds). Generally they contain much humus, charred plants' remnants and fragments of wood. However according to the results of palynologic investigations (Kijewice, Kuskowo) much redeposited and mixed pollen is contained in them (Z. Dłużakowa, 1975; Z.Janczyk-Kopikowa, 1982). General lack of $CaCO_3$ (in places only slender content), usually good roundness of quartz grains and high content of minerals resistant to mechanical weathering reflect accumulation under temperate climate conditions (J.Rzechowski et al., 1981).

At Przasnysz the sandy deposits situated in the same position as a fluvial series described above (71–84 m a.s.l.) are of different character. In the lower part they are slightly of till type, rich in $CaCO_3$ (over 10%) and with bad rounded quartz grains. Upward the profile carbonates' content decreases to zero but quartz grains roundness remains still bad. TL analysis revealed the age of the middle part of the deposits (551±66 ka BP; Lu 134). This dating seems to be comparable to TL dating of fluvial series at Sebory (490±59 ka BP; Lu 142). Both of results are higher than datings connected with Mazovian Interglacial (L.Lindner, 1981) and probably reflect the early phase of warm period or the decline of Wilga Glaciation.

MIDDLE-POLISH GLACIATION

Because of the fluvial Mazovian series in the basement, the stratigraphic separateness of the Middle-Polish suite is very distinct. The complex comprises morainic, fluvioglacial and ice-dammed deposits which probably represent three stadials (Maximum, Warta and Wkra). So far there are no grounds for subdividing the suite glacial and interglacial units. As the area described was out of range of Vistulian ice sheet the present landscape was formed by the processes connected with the retreat of Wkra ice sheet.

The correlation of the Middle-Polish morainic horizons has been confirmed by petrographic coefficients (generally low values of O/K and A/B). They are very similar each to other in case of Maximum and Wkra Stadials and slightly higher if Warta Stadial is considered. Maybe we deal with stratigraphic lithotype of tills which covers particular region (J.Rzechowski, 1977). These tills are less abundant in local gravels (generally 3–7%) throughout the area described however the gravels' content is most diversified there. The gravels of different Tertiary basement deposits as well as Mesozoic limestones (which are more frequent than in older horizons) are represented in all Middle-Polish till layers.

The heavy minerals' assemblage compound, examined in different age till series, revealed that the younger the till layer the smaller the local component' content. The Middle-Polish tills are of lowest values of garnets content as well as they contain less

zircons, tourmalines and glauconite. Among major components amphiboles are frequent. Pyroxenes content is relatively high, too.

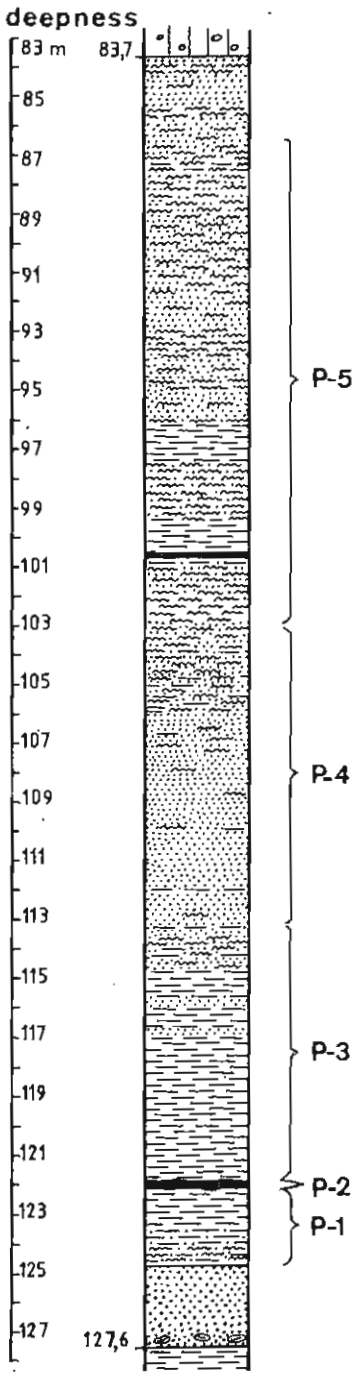
RESULTS OF PALAEOBOTANICAL STUDIES OF INTERGLACIAL DEPOSITS FROM PRZASNYSZ

In the Przasnysz profile samples for palaeobotanical studies were taken from 41 m thick series of deposits at a depth 124.8–83.7 m (Fig. 6). These are different clays, silts and very fine sands with variable organic matter content and two thin laminae of peat at 122.2–121.9 and 100.7–100.5 m. Studies were carried out by the methods of pollen and macroscopic analyses.

Laboratory preparation of samples designed for pollen analysis was very time-consuming, because fine clays were extremely hard to remove. Sodium pyrophosphate was therefore used as clay deflocculant for all samples (C.D.Bates et al., 1978); hot hydrofluoric acid and acetolysis were also applied. Unfortunately, even this combination of methods failed to give satisfactory results in some zones, but the quality of samples was generally improved and in most samples made it possible to count sufficiently large pollen sums.

The results of the pollen analysis of these deposits proved very difficult to interpret because of the occurrence of Tertiary sporomorphs in all the layers of this series except for a compressed peat layer, 30 cm thick, at a depth of 122.20–121.90 m. The Tertiary sporomorphs either show a state of preservation similar to that of the taxa common to the Quaternary and Tertiary or are heavily deteriorated, most frequently degraded or amorphous. This differentiation of preservation of Tertiary sporomorphs occurs in the same samples, making it difficult to establish which of the Tertiary taxa and in what proportion are undoubtedly connected with the redeposition of earlier sediments and which may be referred to the autochthonous flora of Przasnysz. In order to estimate the influence of the Tertiary element on the picture of pollen stratigraphy, two basic sums were used in percentage calculations. In the first version the percentage values were calculated in the way routinely applied for Quaternary deposits. Here the basic sum is the pollen sum of trees, shrubs and terrestrial herbs, excluding the local and the Tertiary element, which was calculated in relation to the basic sum increased by it. In the second version the Tertiary sporomorphs were added to the previous sum but only those resembling the sporomorphs common to the Quaternary and Tertiary in their state of preservation. The proportion of degraded and amorphous Tertiary sporomorphs acknowledged for certain to have been redeposited was calculated in relation to this sum.

The picture of the pollen sequence obtained with both methods of percentage calculation is interglacial in character. The changes occurring in the pollen sequence permitted my distinguishing five local pollen assemblage zones. They are designated



with the capital P for Przasnysz and numbered from the bottom of this series of deposits upwards.

Z o n e P-1 *Pinus-Picea-Alnus* (124.80–122.20 m). Although the sporomorphs are generally in a poor state of preservation, some of them, both of Quaternary and Tertiary origin, have survived in good condition. The frequency is very low. Charcoal dust and abundant detritus, above all, wood detritus, are present in the samples. There are numerous indeterminable fragmentary sporomorphs.

Pollen of *Pinus sylvestris* type prevails among the Quaternary taxa, but *Alnus glutinosa* type and *Picea* also have comparatively high pollen values. Out of the thermophilous trees and shrubs, *Quercus*, *Ulmus* and, in the younger part of the zone, *Corylus* occur in the highest numbers, but always forming less than 4% of the sum of the Quaternary element. Pollen of other Quaternary trees occurs sporadically. The pollen values of herbs reach 20%. Quantitatively they are chiefly represented by *Cyperaceae* and *Gramineae*, but the diversity of other taxa is fairly great. This is mainly pollen of the plants of wet habitats or at least those periodically inundated. Pollen of aquatic and reedswamp plants appears sporadically.

The Tertiary sporomorphs are very abundant in this zone (about 20–50% of the AP + NAP sum). Most of them are degraded and amorphous pollen grains of various saccate *Coniferae* and *Pinus haploxylon* type. The variety of taxa (not always deteriorated) is relatively great. Indeterminable sporomorphs because of their

Fig. 6. Profile of the interglacial deposits at Przasnysz

Explanations – see Fig. 3; P-1 – P-5 — pollen zones after K.Mamakowa

Profil osadów interglacjalnych z Przasnysza

Objaśnienia jak dla fig. 3; P-1 – P-5 – poziomy pyłkowe wg K.Mamakowej

deterioration and *Hystrichosphaeridae* are also abundant.

Z o n e P-2 *Picea-Alnus* (122.20–121.80 m). Part of sporomorphs are heavily corroded, particularly in samples from the lower part of the zone. The samples are characterized by a very high proportion of detritus, especially of detritus herbosus. The frequency of sporomorphs is higher than in Zone P-1. The Tertiary element is missing from the samples examined so far. The spectra are pure Quaternary ones. They are dominated by *Picea* and *Alnus glutinosa* type pollen. The *Pinus sylvestris* type pollen values decrease considerably. The appearance of *Taxus* pollen, unobserved in the preceding zone, is a very important feature of this zone. It attains nearly 5%. Other trees are represented by pollen values reaching 2% or by quite sporadic pollen grains. The herb pollen values lie below 20% and include chiefly pollen of *Gramineae*. As regards reedswamp plants, pollen of *Typha latifolia* and *Phragmites* type is noted, while *Sparganium* type appears in abundance in the upper part of the zone. Of the aquatic plants the appearance of *Salvinia* is noteworthy. Spores of *Polypodiaceae* are very abundant.

Z o n e P-3 *Carpinus-Abies-Quercus* (121.90–113.40 m). The sporomorphs of this zone are in a fairly good state of preservation, though in its lower part many of them are indeterminable for corrosion. In the upper part of the zone percentage of indeterminable sporomorphs becomes lower but the variety of classes of deterioration increases. Most of the Tertiary sporomorphs, which reappear in this zone, resemble the Quaternary taxa in respect of their preservation. Charcoal dust occurs in many samples, vivianite is present in the lower part of the zone and large amount of varied detritus in the upper part. The frequency of sporomorphs is very high.

Alnus glutinosa type pollen attains the highest percentage values of all the Quaternary taxa, but the relatively high pollen values of *Carpinus* (to 14%), *Abies* (to 20%) and *Quercus* (to 18%) are characteristic of this zone.

The zone has been divided into two subzones: P-3a (121.9–118.5 m) and P-3b (118.5–113.4 m). In subzone P-3a *Taxus* has high pollen values (to about 8%). The proportion of Tertiary sporomorphs is low and does not exceed 3%. Subzone P–3b is characterized by a continuous rise in the values of *Pterocarya* (to about 10%); its pollen shows the same state of preservation as that of the Quaternary tree pollen. The percentages of other Tertiary taxa also rise in this subzone. Some of them are as well-preserved as the Quaternary taxa, nevertheless many are degraded and amorphous.

The percentage values of other trees and *Corylus* are low throughout the zone, but still the highest in the interglacial. *Buxus, Vitis, Ligustrum, Ilex aquifolium* type and *Viscum* appear for the first time. Aquatic and reedswamp plants are represented by low pollen values and rather in a discontinuous way at that. Relatively frequent are fragmentary microsporangia of *Salvinia*, while sporadic fragments of massulae with glochidia belonging to *Azolla filiculoides* appear here for the first time.

Z o n e P-4 *Pinus-Betula*-NAP (113.40–103.00 m). Most of both Quaternary and Tertiary sporomorphs are fairly well preserved except for the top section of the

zone, where, besides, their frequency comes down. However, sporomorphs which are indeterminable for various classes of deterioration are present in the whole zone. Charcoal dust occurs in all samples and detritus abounds.

Pinus sylvestris type pollen dominates all through the zone, with values exceeding 40% on its very threshold. The proportion of tree birch pollen also increases slightly (max. about 11%). The pollen values of trees which had their maxima in the preceding zone, i. e. *Abies, Carpinus, Quercus, Taxus, Pterocarya*, fall rapidly and do not exceed 2–3% now, *Taxus* being even noted only sporadically. The proportion of other thermophilous tree pollen is slight or they occur but sporadically. Parallel to these changes in trees, the pollen values of herbs rise. *Cyperaceae* and *Gramineae* prevail but the variety of taxa representing various habitats (*Menyanthes*, *Caltha* type *Filipendula*, *Sanguisorba officinalis*, *Rhinanthus* type, *Artemisia*, *Rumex acetosella* type, cf. *Papaver*, *Helianthemum nummularium* type, etc.) increases. *Selaginella selaginoides* appears occasionally. As far as aquatic and reedswamp plants are concerned, microsporangia of *Salvinia* and pollen of *Typha latifolia* and *Sparganium* type are comparatively often noted. *Azolla filiculoides* occurs in several samples. Other taxa appear sporadically. The proportion of well-preserved Tertiary taxa is not high and, excluding *Pterocarya* pollen, it ranges between 4 and 7%. Its value grows in the top samples of the zone, where the proportion of deteriorated Tertiary sporomorphs, *Hydrotrichospharidae* and marine plankton also rises.

Z o n e P-5 *Cyperceae-Gramineae-Betula nana* (103.00–87.70 m), is hydrologically disturbed at a depth of 96.70–94.40 m. This section is not included in the description of the pollen zone. The state of preservation of sporomorphs in zone P-5 compares with that in the lower part of the preceding zone. Their frequency is high in the lower part of the present zone but low above the hydrologically disturbed layer. Charcoal dust, vivianite and very abundant detritus are present in the samples.

Herb pollen is dominant, with its values reaching about 60%. *Pinus sylvestris* type is the most numerous tree (to about 45%). As regards herbaceous plants, *Cyperaceae* pollen prevails, while that of *Gramineae* shows lower values. The herbs of this zone are not diversified very much in respect of taxa. Fairly frequently noted, though with low percentage values, are *Artemisia, Chenopodiaceae, Compositae Tubuliflorae, Rosaceae, Ranunculus acris* type, *Filipendula* and *Thalictrum*. *Armeria*, *Selaginella selaginoides* and *Botrychium* are noted sporadically. In addition to *Pinus sylvestris* type, trees are represented by continuously occurring pollen of tree birches (*Betula alba* type), *Alnus glutinosa* type and *Picea*. Pollen of thermophilous trees appears sporadically. The almost continuous presence of *Betula nana*, *Juniperus* and *Salix glauca* type pollen (to about 5, 4 and 11% respectively) is characteristic of this zone. Pollen of *Hippophaë* and *Ephedra distachya* type occurs occasionally and so does that of aquatic and reedswamp plants. The percentage of Tertiary taxa are relatively low (1–14%).

Within the hydrologically disturbed layer sporomorphs are exceptionally heavily deteriorated (degraded, amorphous and crumpled). This is true of both Quaternary and Tertiary taxa. The proportion of Tertiary taxa is very high, reaching about 60% of

the AP + NAP sum. The values of sporomorphs indeterminable for various classes of deterioration and the proportion of *Hystrichosphaeridae* also rise here. In this section the frequency of sporomorphs is very low, mainly because of the exceptionally large amounts of varied detritus, charcoal dust and clay. The results of pollen analysis are utterly unreliable.

A macroscopic analysis has shown the presence of relatively numerous plant remains in zone P-2, subzone P-3b, lower part of P-4 and in some sections of zone P-5. The macrofossils of identified trees and shrubs are usually well correlated with the significance of their pollen in the assemblage zones. Macrofossils of *Alnus glutinosa*, *Abies*, *Carpinus* (sporadical), *Acere Pterocarya*, *Sambucus*, *Pinus sylvestris*, *Larix*, *Salix*, *Betula nana* and other taxa have been found. As regards aquatic plants, the presence of *Azolla*, *Salvinia natans*, *Najas marina*, *N.minor*, *Characeae*, *Stratiotes aloides*, *Cyperus glomeratus* and *Typha* is worthy of attention.

The sequence of the pollen assemblage zones distinguished in the profile at Przasnysz permits the statement that the vegetational succession of this section of Pleistocene was of an interglacial nature, with the upper boundary of the interglacial marked by the upper boundary of zone P-4 *Pinus-Betula*-NAP. Zone P-5 *Cyperaceae-Gramineae-Betula* reflects an already distinctly cold oscillation with tundra-type vegetation. The presence of Tertiary taxa, almost continuous but in changing proportions and in various states of preservation, makes the interpretation of data difficult, although it does not deny the interglacial nature of this vegetational succession. A decided majority of Tertiary taxa are redeposited but, most likely, that is not the case in so far as *Pterocarya*, *Azolla filiculoides* and probably also several other taxa are concerned.

The sequence of pollen zones characterized by 1 — an early culmination of spruce (*Picea*) and alder (*Alnus*), 2 — a culmination of hornbeam (*Carpinus*) and fir (*Abies*) following the previous trees, 3 — a low proportion of hazel (*Corylus*), lime (*Tilia*) and elm (*Ulmus*), and a somewhat higher proportion of oak (*Quercus*) in the climatic optimum and 4 — high values of pine (*Pinus*) pollen somewhat lower values of tree birches (*Betula alba* type) at the decline of the interglacial, is typical of the Mazovian Interglacial in Poland and corresponds with pollen periods II – IV in W. Szafer's scheme (1953). The presence of *Azolla filiculoides* and *Pterocarya* also make a characteristic feature of the Mazovian Interglacial in Poland. In recent years yew (*Taxus*) has been reported from many profiles referred to this interglacial; it usually reaches the highest pollen values directly before the maximum expansion of hornbeam and fir.

The percentage of *Pterocarya* pollen at Przasnysz, reaching 10% is higher than in other Mazovian sites in Poland. The highest values noted so far at Olszewice, Gościęcin, Włodawa, Suszno and Nowe Sioło do not exceed 4% of the AP sum (M.Sobolewska, 1956; A. Środoń, 1957; A.Stachurska, 1957, 1961; W. Laskowska-Wysoczańska, J. Oszast, 1990). However, high values of *Pterocarya*, similar to those from Przasnysz, are reported by K.Erd from Holstein sites in Eastern

Germany (A.G.Cepek, K.Erd, 1975; K.Erd, 1978). Also the culmination of yew (*Taxus*), somewhat earlier at Przasnysz than at other Mazovian sites in Poland, resembles the culmination occurring in the Holstein Interglacial at Wildschütz (37E/69) and at Pritzwalk (1E/61) in Eastern Germany (K.Erd, A.Müller, 1977; K.Erd, 1978).

REMARKS ON THE STRATIGRAPHIC CORRELATION

The stratigraphy of Pleistocene deposits presented in the paper corresponds with a currently accepted Polish subdivision which is referred to the European standard. According to stratigraphic subdivisions by L.Lindner (1988) and M.D.Baraniecka (1990) glacial deposits of Narew Glaciation (Günz) are correlated with early Pleistocene non glacial deposits Menap and Unstrut from Western Europe. Podlasie Interglacial is considered an equivalent of Early Cromerian (I) and Nida Glaciation is supposed to be relevant to the Glacial A of the Cromerian complex in Holland. Przasnysz Interglacial (Małopolian) is accepted to be parallel to Korczew Interglacial in Byelorussia as well as to Cromerian II (J.E.Mojski, 1985; L.Lindner, 1988). In the surroundings of Przasnysz glacial stages of San (Glacial B in Holland, Elstera 1) and Wilga (Elstera 2) are separated by Kurpie Interglacial which has a TL date similar to Ferdynandów Interglacial (Z.Janczyk-Kopikowa et al., 1981; J.Rzechowski, 1986). In the opinion of some authors (e.g. K.Erd, 1978; J.E.Mojski, 1985) Ferdynandów Interglacial corresponds with Voigstedt in Germany. However L.Lindner (*l.c.*) correlated it with Cromerian III and IV in Holland. The position of Mazovian Interglacial (Mindel-Riss, Holstein, Lichwin) seems to be defined precisely and does not evoke any doubt. Middle-Polish Glaciation (Riss, Saalian, Dniepr), usually divided into two individual glaciations of Odra and Warta (S.Z.Różycki, 1980; L.Lindner, 1984; M.D.Baraniecka , 1990) is suggested to be one glacial stage composed of three units of stadial rank.

The results of the present palaeobotanic study of the Przasnysz profile, showing a pollen sequence resembling that in the Mazovian (= Holstein) Interglacial in its nature, agree with the view published by W.Selle (1960), who, on the basis of pollen analysis concerning a profile bored in 1941, acknowledged this interglacial as Mindel-Riss (Holstein Interglacial). W.Selle (l.c.) did not reach zones P-1 and P-2, included in the present profile. He distinguished only the fir, fir-pine and pine zones, which correspond with zones P-3, P-4 and presumably also P-5 based on the present findings.

The nature of the pollen sequence from Przasnysz differs completely from that in three older interglacials of the Cromerian complex. Cromerian I (type site at Waardenburg, W.H.Zagwijn et al., 1971; W.H.Zagwijn, 1974, 1975, 1985, 1989; J. de Jong, 1988), correlated with the Cromerian Interglacial from Osterholz in Germany

(E.Grüger, 1967) is characterized by the *Carpinus-Eucommia* zone in the younger part of the interglacial and the high pollen values of *Ulmus* (above 30%) and *Quercus* (25 – about 50%) at the onset the interglacial (cf. E.Grüger, 1967). Cromerian II in the Netherlands (Westerhoven) with an incomplete plant succession is correlated with the Danish Harrescovian Interglacial (W.H.Zagwijn, 1974).It is marked by very high pollen values of *Ulmus* and *Quercus* at the beginning of the interglacial, then high values of *Taxus* and lack of *Abies* and *Carpinus* in its younger part, which ends in late culminations of *Picea*, *Pinus* and *Betula* (see S.Th.Andersen, 1965). Cromerian III is represented by the sites considered earlier to be the Holstein Interglacial (W.H.Zagwijn, 1974, 1985, 1989; J. de Jong, 1988). Characteristic of this interglacial are the low values of *Carpinus* at its beginning, the *Picea* zone at the end and the lack of *Abies* (J. de Jong, 1988). Cromerian IV in the Dutch Cromerian complex is similar to the Holstein Interglacial (= Mazovian) and earlier used to be confused with it (W.H.Zagwijn, 1974; J. de Jong, 1988). It has a zone with *Abies* and *Carpinus* but of considerably lower values than in the Mazovian Interglacial. The plant succession at Przasnysz comes near also to the Cromerian succession (sensu typico) in England (R.G.West, 1980), which resembles the Hoxnian Interglacial (= Holstein Interglacial).

The possibility of correlation of Przasnysz Interglacial with Interglacial IV of the Cromerian complex in Holland allows to refer Nida Glaciation to this complex as well. In the vicinities of Przasnysz Nida Glaciation is represented by uniquely well developed complex of deposits which comprises at least three morainic horizons. Probably Bavelian complex (W.H.Zagwijn, J. de Jong, 1984; W.H.Zagwijn, 1989) is also represented there. Maybe fluvio-lacustrine deposits at Kijewice, where TL dates are comparable to Jaramillo Event, are parallel to Bavel Interglacial. Thus the oldest morainic deposits of Przasnysz are likely correlable with Menapian cooling in Holland.

Hitherto roughly recognized in Poland early Pleistocene deposits are uniquely well preserved at Przasnysz. Most probably the present stratigraphic subdivision does not reflect their complicated character entirely. Actually some secondary units are possibly of higher rank than described in the present paper. New data concerning this problem will be provided due to following investigations on the deep sub-Quaternary depressions.

Zakład Kartografii Geologicznej
Państwowego Instytutu Geologicznego
Warszawa, ul. Rakowiecka 4
Instytut Botaniki im.W. Szafera PAN
Kraków, ul. Lubicz 46
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Alicja BAŁUK, Kazimiera MAMAKOWA

POZYCJA STRATYGRAFICZNA OSADÓW INTERGLACJALNYCH Z PRZASNYSZA

Streszczenie

Głównym celem badań nad plejstocenem okolic Przasnysza było szczegółowe rozpoznanie osadów interglacjalnych opisanych przez W. Sellego (1960), który na podstawie analizy palinologicznej kilkunastu próbek tych osadów określił ich wiek na interglacjał mazowiecki (Mindel-Riss Interglazial). Odmienny pogląd przedstawił S.Z.Różycki (1967), uznając interglacjał z Przasnysza za odpowiednik interglacjaLu najstarszego, paralelizowanego z kromerem. Dyskutowany profil do głębokośei 150,5 m nie osiągnął spągu czwartorzędu.

W ramach prac geologiczno-kartograficznych Instytutu Geologicznego wykonano w okolicach Przasnysza 5 wierceń badawczych (fig. 1), z których jedno zostało usytuowane w miejscu otworu opisanego przez W.Sellego (*l.c.*). We wszystkich tych wierceniach przebito osady pleistoceńskie o dużej miąższości (170–258 m), co świadczy o istnieniu tu głębokiego obniżenia (do 100–129 m p.p.m.) w powierzchni podczwartorzędowej (fig. 2). Powierzchnię tę w obrębie obniżenia tworzą utwory mioceńskie a poza jego zasięgiem — pstre iły pliocenu.

Sytuację geologiczną serii interglacjalnej z Przasnysza przedstawiono w nawiązaniu do sąsiednich, szczegółowo opracowanych profilów badawczych (fig. 3). Na ich podstawie ustalono stratygrafię osadów plejstoceńskich w tym rejonie, wykorzystując wyniki badań litologiczno-petrograficznych, mineralogicznych, paleontologicznych i datowań TL. Wyróżniono tu pięć głównych jednostek glacjalnych, odpowiadających zlodowaceniom narwi, południowopolskim (nidy, sanu i wilgi) i środkowopolskiemu, rozdzielonych czterema interglacjałami – podlaskim (kijewicki), przasnyskim (małopolski), kurpiowskim (ferdynandowski) i mazowieckim.

Korelacja litostratygraficzna wyróżnionych serii morenowych i międzymorenowych dostarczyła podstaw dla ustalenia pozycji interglacjału przasnyskiego w obrębie kompleksu zlodowaceń południowopolskich, między piętrami nidy i sanu (fig. 4 i 5). Interglacjał z Przasnysza nie jest bowiem w tym rejonie ani interglacjałem najstarszym ani też nie odpowiada mazowieckiemu.

Jednakże wyniki szczegółowej analizy paleobotanicznej tych osadów, wykonane przez K.Mamakową i przedstawione w niniejszej pracy, wskazują na obraz roślinności podobny do sukcesji w interglacjale mazowieckim (holsztyński). Autorka analizy rozważa możliwość korelacji interglacjału przasnyskiego z interglacjałem IV-tym kompleksu kromerskiego w Holandii, który pod względem sukcesji roślinności jest podobny do interglacjału holsztyńskiego i był z nim wcześniej mylony.

Możliwość takiej korelacji pozwalałaby wiązać z kompleksem kromerskim także zlodowacenie Nidy, które w okolicach Przasnysza wyrażone jest przez 2-3 poziomy morenowe. Prawdopodobnie zatem, że reprezentowany jest tu również, starszy od kromerskiego, kompleks osadów Bavelianu (W.H.Zagwijn, J. de Jong, 1984; W.H.Zagwijn, 1989). Być może, iż z tym właśnie kompleksem należy paralelizować serię osadów fluwiolimnicznych z Kijewic, o datach TL wskazujących na Jaramillo Event.