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Vistulian Glacial Cycle of the Fluvial Processes Development in the Valley of the Middle Wieprz River (SE Poland)

Vistuliański cykl glacjalny rozwoju procesów fluwialnych w dolinie środkowego Wieprza (Polska SE)

ABSTRACT

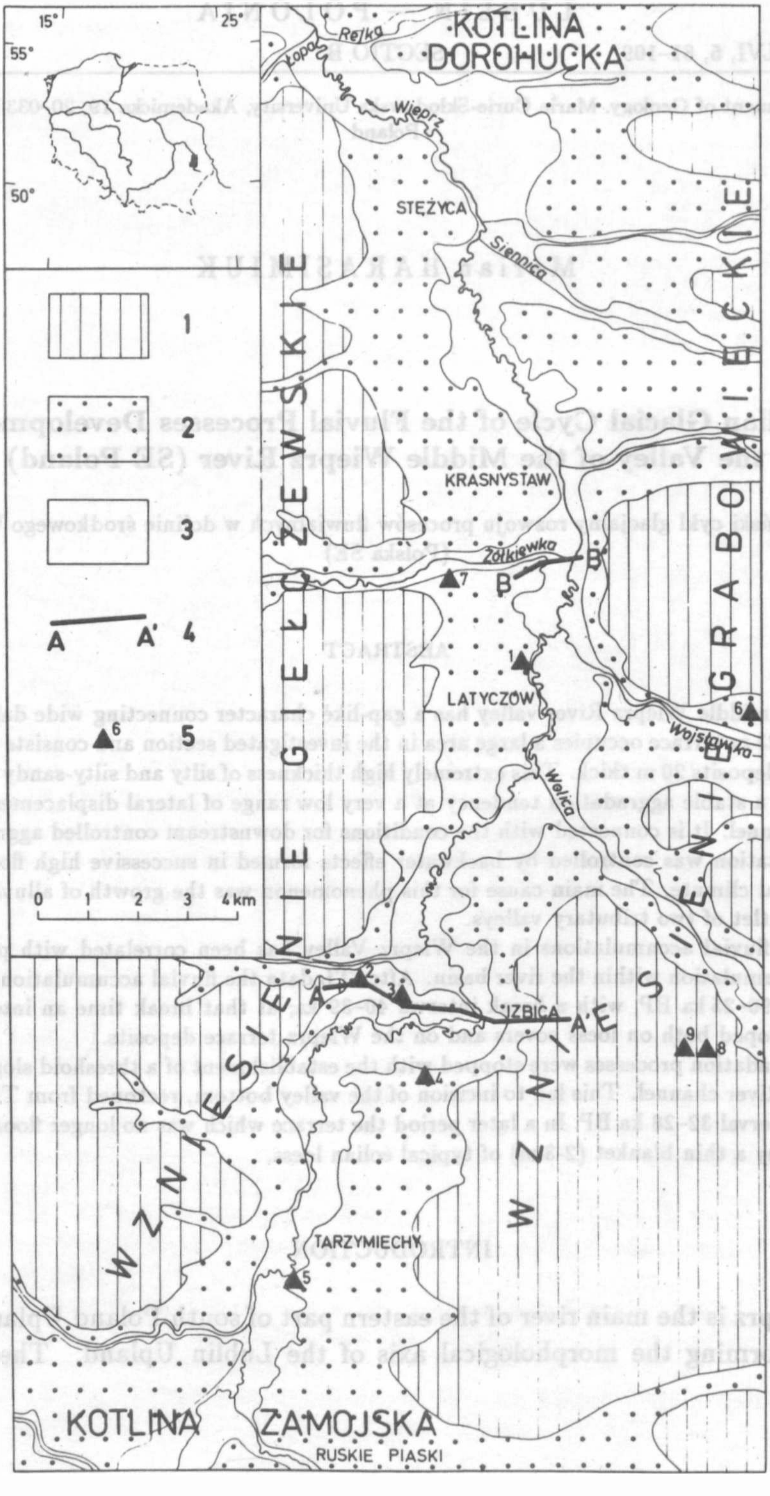
The middle Wieprz River valley has a gap-like character connecting wide dale forms. The 20–23 m terrace occupies a large area in the investigated section and consists of extra-channel deposits 20 m thick. This extremely high thickness of silty and silty-sandy deposits is due to a stable aggradation tendency at a very low range of lateral displacement of the river channel. It is connected with the conditions for downstream controlled aggradation. Sedimentation was controlled by backwater effects formed in successive high floods in a periglacial climate. The main cause for this phenomenon was the growth of alluvial cones at the outlet of two tributary valleys.

The fluvial accumulations in the Wieprz Valley has been correlated with phases of loess accumulation within the river basin. After TL data the fluvial accumulation occured between 90–25 ka BP, with a break interval 40–39 ka; at that break time an interstadial soil developed both on loess covers and on the Wieprz terrace deposits.

Aggradation processes were stopped with the establishment of a threshold slope of the Wieprz River channel. This led to incision of the valley bottom, reckoned from TL dating in the interval 32–28 ka BP. In a later period the terrace which was no longer flooded, was covered by a thin blanket (2-3 m) of typical eolian loess.

INTRODUCTION

Wieprz is the main river of the eastern part of south Poland Uplands, its valley forming the morphological axis of the Lublin Upland. The valley



15°
25°
55°
50°
KOTLINA DOROHUCKA
Rejka
Lopa
Wieprz
STĘŻYCA
Siennica
KRASNYSTAW
Żółkiewka
B
B'
LATYCZÓW
Wojsławka
Wolica
IZBICA
A
A'
TARZYMIECHY
KOTLINA ZAMOJSKA
RUSKIE PIASKI
1
2
3
4
5
0 1 2 3 4 km

consists of several basin like depressions connected with gape segments. The researches were carried out within the gape valley 16 km in length, situated southward of the town Krasnystaw. This valley divides two highest subregions of the Lublin Upland – Grabowiec Elevation in the East and Giełczew Elevation in the West (H. Maruszczak 1972). In years 1983–1985 investigations were made to work out a Detailed Geological Map of Poland 1:50 000 (M. Harasimiuk et al. 1987). Next, in years 1986–1988 these investigations were broadened and particularized by the order of the Institute of Geography of Polish Academy of Sciences (CPBP 03.13).

At this stage both air photos and detailed geomorphological maps 1:10 000 were analyzed. Five large sections of over flood terraces were described and sampled, and additionally, out drilled core outputs were taken into consideration. To obtain a full lithological characterization of fluvial deposits were made 80 grain size analyses by sieve and pipette methods, $CaCO_3$ contents by Scheibler's volume method.

On the basis of the granulometric analysis results we counted the granulation indexes according to R.L.Folk and W.C.Word (1957): mean diameter (Mz), standard deviation (σ), graphic skewness (SK_I) and curtosis (KG'). In the TL Laboratory of the Physical Geography Department of the University Maria Curie-Skłodowska in Lublin dr J.Butrym determined ages for 10 samples of fluvial deposits.

GENERAL GEOMORPHOLOGICAL CHARACTERISTICS OF THE MIDDLE WIEPRZ VALLEY

The investigated part of the Wieprz valley has NNE–SSW direction corresponding to a well-readable on satellite photographs dislocation zone transverse to the Paleozoic structural units of the Lublin Upland (A. M. Żelichowski 1972, J. Bażyński 1985, M. Harasimiuk 1980). In the Mesozoic Era its central part made up a fragment of an extensive syncline structure in which were deposited sea carbonate-silicate sediments of 500–1000 m thickness (W. Pożaryski 1974, A. Krassowska 1977). They are weakly diagenesed rocks of silicate binder of opoka type and gaizes

Fig. 1. General sketch of the study area
1 — interfluve areas; 2 — terraces; 3 — recent floor of the Wieprz River and tributaries; 4 — localization of geological cross sections; 5 — localization of investigated sections (bore holes and outcrops)

as well as limestones, marls and chalk. In these rocks there is cut a valley of the middle Wieprz River (Fig. 1).

The main erosion phase on the Lublin Upland took place in the Eopleistocene (A. Jahn 1956, J. E. Mojski 1964, 1985). Its size in the middle Wieprz valley is estimated at about 80 m. The valley bedrock of the investigated section lies at 125–130 m a.s.l. The deep Eopleistocene valley is filled with a complex of Quaternary deposits (Fig. 2). The lower part of this complex is made up with gravel sands and gravels of only the Upper Maestrichtian and Tertiary rocks. They are covered with silts with a high percentage of micas. These sandy-gravel and silty deposits J. E. Mojski (1985) defines as the Lower Pleistocene stratigraphic unit (Krasnystaw Stage). Above these series there occur layers of a glacial part of the Pleistocene, containing gravels of the Scandinavian rocks. The oldest links of these deposits are two fluvial complexes: gravel-sandy and gravel-silty ones. Dating results by TL methods (Fig. 2) prove them to represent the period before the Nida inland ice transgression (M. Harasimiuk et al. 1987). Above them there are found gravel and sandy gravel deposits of 20 m in thickness with abundant crystalline material. Local rock gravels, especially in upper parts of these deposits, are poorly rounded. The top of these deposits lies at about 180 m a.s.l. Sedimentation of this series could be paralleled with the regressive stages of the San inland ice. During the interval of this glaciation and succesive interglacial a very intensive erosion took place whose results are estimated at 20 m. The valley which was cut in the older deposits was gradually filled with fluvial deposits several sedimentation cycles (M. Harasimiuk, W. Szwajgier 1985).

However, the next stage of filling the valley is connected with the Odra glaciation. At that time, the inland ice maximum range line ran through the environs of Krasnystaw – Rejowiec – Chełm (A. Jahn 1956, J. E. Mojski 1964, H. Maruszczak 1972, M. Harasimiuk 1975). The valley was then filled with sandy and sandy-gravel deposits up to the height of 210–215 m a.s.l., i.e. at 30 m above the present bottom level. With the Odra inland ice regression is connected the subsequent erosion stage which much removed the maximum glaciation stage deposits. The erosion range can be estimated at 30 m. In the Wieprz tributary valleys the erosion was significantly smaller.

In the Warta glaciation the investigated part of the valley was filled with silty and silty-sandy deposits typical for overflow and flood formations. The series of these deposits reached the thickness of 15 m. A successive erosion stage took place at the end of this glaciation and the beginning of the Eemian. The erosion effects can be estimated at about 15–20 m. Then, a valley of 500 m in width and with the bottom of 168–170 m a.s.l. was formed. In comparison with the width of the whole valley the depression was relatively narrow and was filled with stream-channel facies deposits of up to 10 m in thickness (Fig. 2 and 9). Slopes of this interglacial valley were chiefly built of firm silty deposits of the Warta glaciation. These deposits also formed a very extensive over flood terrace. On the preserved surface of this terrace covered by younger deposits there was found well-developed forest soil (Fig. 7 and 11), which corresponds to the intraloess, interglacial soil so well known from many profiles on the Lublin Upland (J. E. M o j s k i 1968, L. D o l e c k i 1981, H. M a r u s z c z a k 1987).

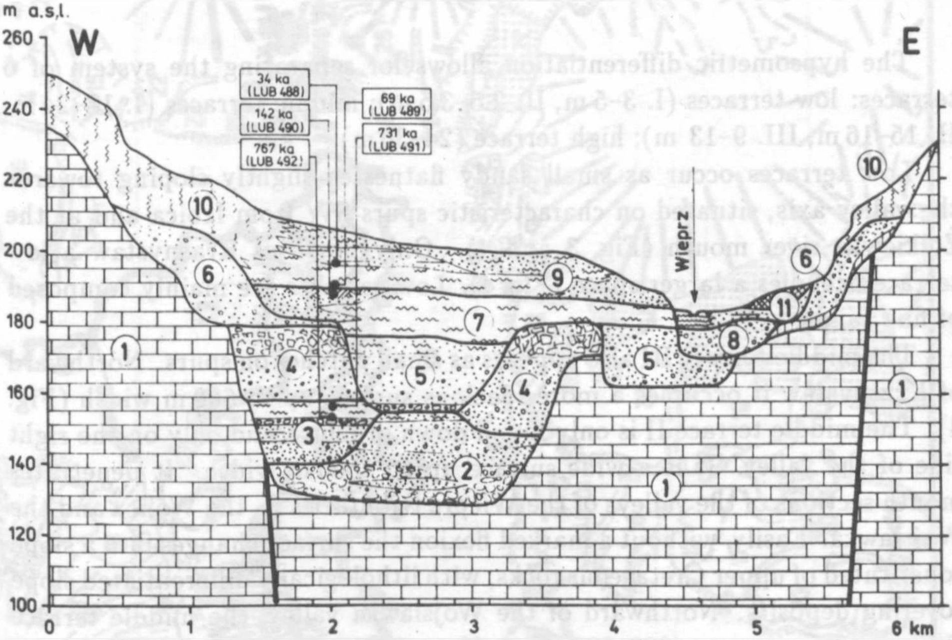


Fig. 2. Geological cross section of the Wieprz Valley in Izbica along line A — A (after M. Harasimiuk et al., 1987 — generalized)
Age of sedimentary complexes: 1 — upper Cretaceous; 2 — Eopleistocene; 3 — older part of middle Pleistocene (before San glaciation); 4 — San glaciation (South — Polish glaciation); 5 — Mazovian interglacial; 6 — Odra glaciation; 7 — Warta glaciation; 8 — Eem interglacial; 9 and 10 — Vistulian; 11 — Holocene. Explanation to lithological signatures see Fig. 6. TL data after J. Butrym

RELIEF OF THE GAP PART OF THE WIEPRZ VALLEY

In the Wieprz valley southward of Krasnystaw A. J a h n (1956) distinguished two main morphological surfaces: the present valley bottom i.e. the flood plain, and terrace of differentiated relative height form 15 to 23 m and sometimes even to 30 m. A. Jahn (1956) explained such a big differentiation of the terrace height by cutting of the concave surface of the valley bottom formed with considerable participation of slope processes.

Flood plain reaches 1.5–2 m above the average water level in the river bed. Its width ranges from 500 m to 1500 m. There are only two distinguishable narrowings in Izbica and in Krasnystaw, where the width of the present bed does not exceed 300 m.

THE TERRACES SYSTEM

The hypsometric differentiation allows for separating the system of 6 terraces: low terraces (I. 3–5 m, II. 2.5–3.5 m); middle terraces (I. 18–24 m, II. 15–16 m, III. 9–13 m); high terrace (24–30 m).

Low terraces occur as small sandy flatnesses slightly sloping towards the valley axis, situated on characteristic spurs SW from Izbica and at the Żołkiewka river mouth (Fig. 3 and 4). Only north of Krasnystaw a low terrace occupies a larger space (Fig. 4). Low terraces are mainly composed of fine sands.

The middle terrace III also appears as small patches on spurs. Northward of Krasnystaw it occupies a more spacious surface up to 600 m width (Fig. 4). The middle terrace II is only found down of Izbica and only on the right side of the valley. It is a wide surface up to 1500 m width. It penetrates mouth sections of the valleys of the Wieprz tributaries — the Wolica and the Wojsławka. Easily, without a marked flexion the surface changes into a slope constituted of upper Cretaceous rocks, with lithologically differentiated slope covering deposits. Northward of the Wojsławka valley, the middle terrace II is seen as a narrow (200–300 m) shelf markedly sloped to the valley axis. Still, to the north of the Żołkiewka mouth, the terrace of relative height of 15–17 m occupies wide spaces on both sides of the Wieprz, thus creating the basic element of the Dorohucza Depression relief.

In the gap section between Tarzymiechy and Krasnystaw, there dominates the middle terrace I of the relative height 18–24 m (Fig. 3). It is characterized by almost constant absolute height on the whole length of the gap (about 200–205 m a.s.l.). Thus the relative height increases down the valley from 18–20 m in the vicinity of Tarzymiechy to 20–24 m in the environs of Latyczów (Fig. 3–5). Three morphological sections of this terrace may be separated on the investigated area. In the upper section (up to Izbica environs) it appears on the east side of the valley (Fig. 3). It cre-

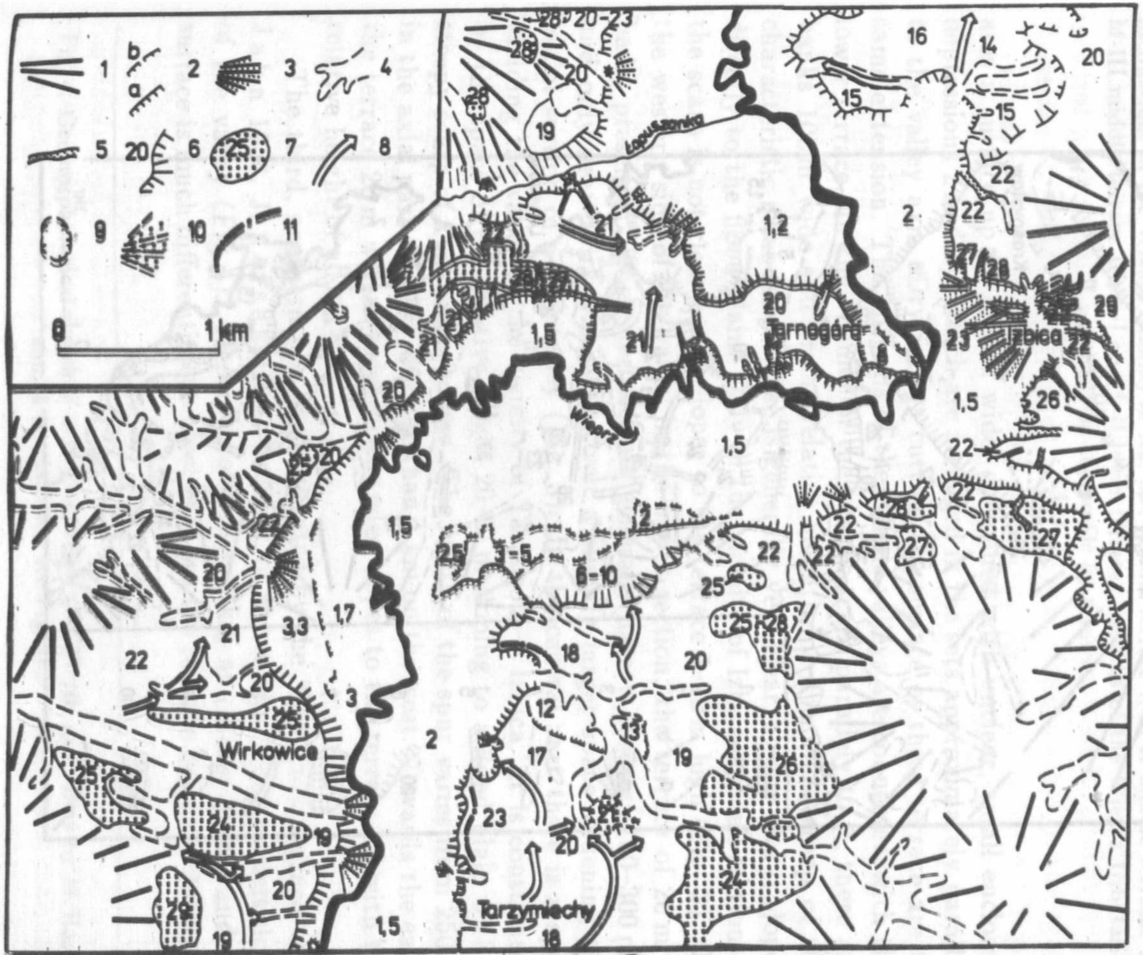
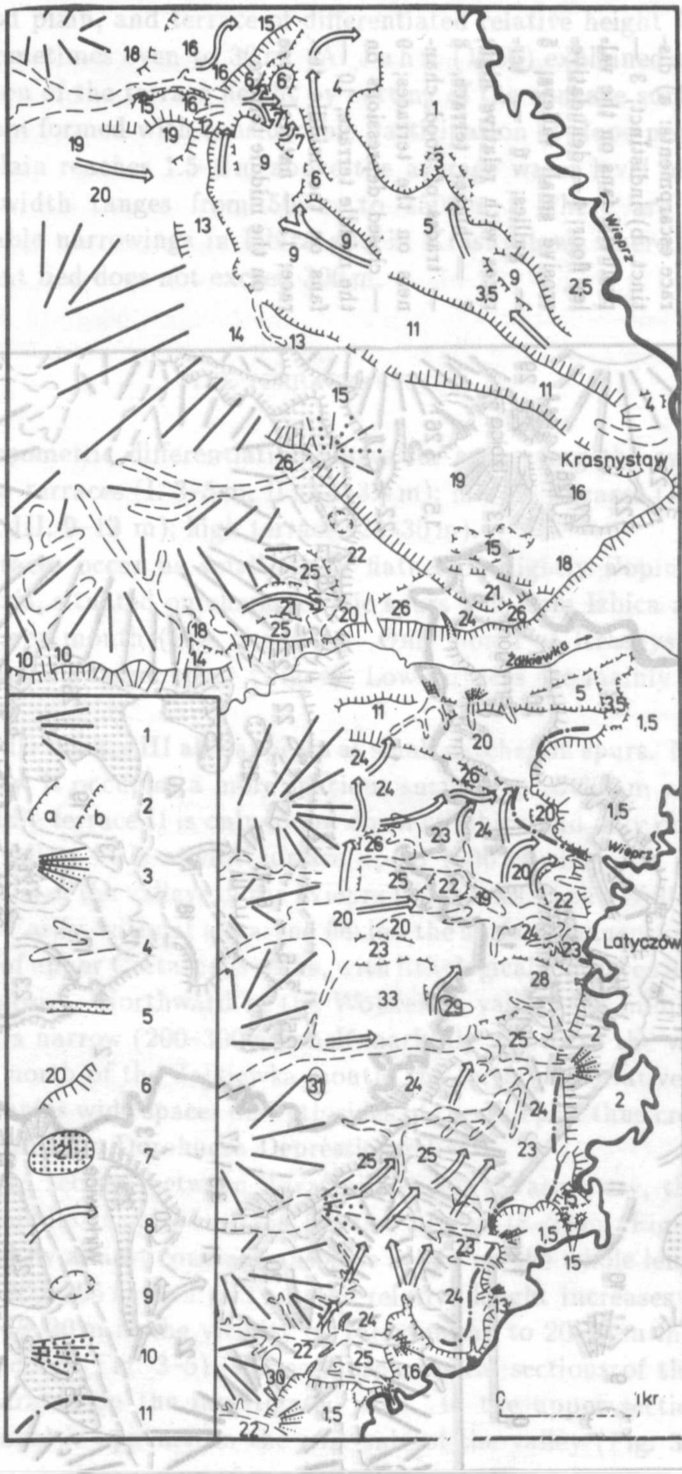


Fig. 3. Geomorphological sketch of southern part of the Wieprz gap valley (by M. Harasimiuk)

1 — slopes; 2 — terrace escarpments: a) distinct, b) indistinct; 3 — proluvial fans on the valley floor; 4 — denudative-erosive small valleys; 5 — gullies; 6 — terraces with relative high; 7 — higher terrace; 8 — traces of flood channels on the terraces; 9 — closed depressions on the middle terrace; 10 — fans on the middle terrace; 11 — natural levee on the middle terrace


Wieprz
Krasnystaw
Żółkiewka
Wieprz
Latyczów
0
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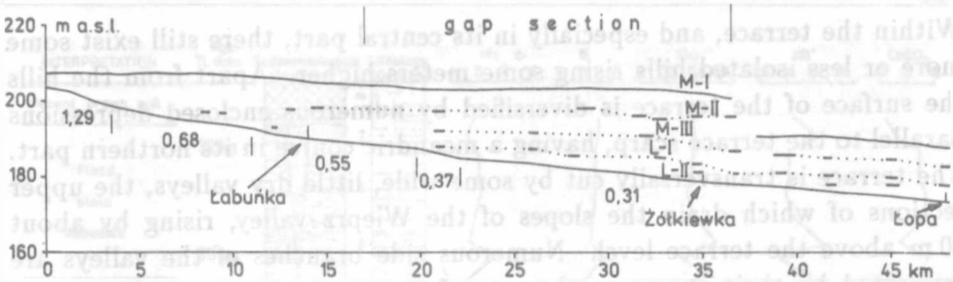

Fig. 5. Longitudinal profile of the Wieprz valley gap
Inclinations of the Wieprz channel in ‰; M-I middle terrace I; M-II middle terrrace II; M-III middle terrace III; L-I and L-II lower terraces; mouths of the Wieprz tributaries marked on the profile by arrows

ates a surface up to 1500 m wide, diversified with unclear, small enclosed depressions 2 m deep, which are arranged in the sets approximately parallel to the valley axis. Dry valleys cutting the surface of these terrace are to same extension. The bottoms of these little valleys are connected with the lower terrace. In the vicinity of the terrace scarp parallely to it, there are banks 100 m wide and of the relative height of 3–4 m. The scarp of the characteristic meander's course is generally very clear, steepy and it slopes directly to the flood plain. Only in the vicinity of Izbica a small section of the scarp is not clear and it slopes to the terrace 6–10 m high (Fig. 3). On the western side of the valley in the upper section, the terrace of 20 m is badly preserved. These terraces are generally narrow shelves (100–300 m), and only near Wirkowice they cover a slightly larger space widening the outlet section of a side valley (Fig. 3). In the central part there is a spur dividing the valley in the vicinity of Tarnogóra— Izbica. It is constituted by the space of the relative height 20–21 m sloping to a flood plain with a steepy scarp of a meandric course. The width of the spur varies from 250 m in the axial part of valley to more than 1 km on the west. Towards the east, the terrace 20 m with a very unclear edge slopes to the terrace III with the relative height of about 8 m.

The third, northern part is constituted by the "Latyczów terrace" (A. Jahn 1956, J. Jersak 1976), running for about 6 km along the left slope of the valley (Fig. 4). Its width oversteps 2 km at certain places and its surface is much differentiated. Most of it has the relative height of 23–25 m.

Fig. 4. Geomorphological sketch of northern part of the Wieprz gap valley by M. Harasimiuk (explanation see Fig. 3)

Within the terrace, and especially in its central part, there still exist some more or less isolated hills rising some meters higher. Apart from the hills the surface of the terrace is diversified by numerous enclosed depressions parallel to the terrace scarp, having a meandric course in its northern part. The terrace is transversally cut by some wide, little dry valleys, the upper sections of which drain the slopes of the Wieprz valley, rising by about 60 m above the terrace level. Numerous side branches of the valleys are connected by their course to the sets of denudations. Along the terrace edges of meandering course, narrow (up to about 100 m) banks of relative height 1–3 m above the terrace level run for considerable distances. Only in the vicinity of Latyczów, where the Wieprz is now approaching terrace scarps and at certain points undermining them, the scarp banks do not exist (Fig. 4). From the north the surface of this terrace is limited by the bank 150 m wide, rising above it by 2–3 m and sloping with a quite clear scarp towards the terrace in the Żołkiewka river valley.

Along the whole gap section of the valley there are fragments of a high terrace of the relative height 24–28 m. In the southern part of the gap section they show the nature of a typical terrace formed of sand and sandy-gravely formations covered by loess or silty deluvia (Fig. 3). The situation is not so explicit in the "Latyczów terrace". These fragments may be also interpreted as flat fans adding to the middle terrace I (A. J a h n 1956).

THE GEOLOGICAL STRUCTURE OF MIDDLE TERRACE I

The geological structure of a middle terrace I in the Wieprz valley was examined in detail owing to 3 large outcrops (Fig. 1, sites 1, 4, 5) and the core drillings (Fig. 1, sites 2, 3, 6). Analysis of the several drilling wells profiles situated at various points on this terrace allows for a statement that the presented sections are representative and well characterize its internal structure (Fig. 6–8). Generally, the spatial differentiation of the terrace deposits is slight in the longitudinal and transversal profiles. Also the variability character in vertical profiles allows for correlating particular outcrops or drilling wells profiles.

In the southern part of the gap the Vistulian sedimentation began from the surface raised above the present water level in the Wieprz from 2 m in the peri-axis zone, to 5–6 m in the peri-slopes. At all analyzed sites this terrace is basically made up with greenish silts ("dryas type") Wartanian age. Interglacial soil is preserved here and there on the silts (Fig. 2 and 7). At the northern part of the gap, up to Krasnystaw these silts appear below

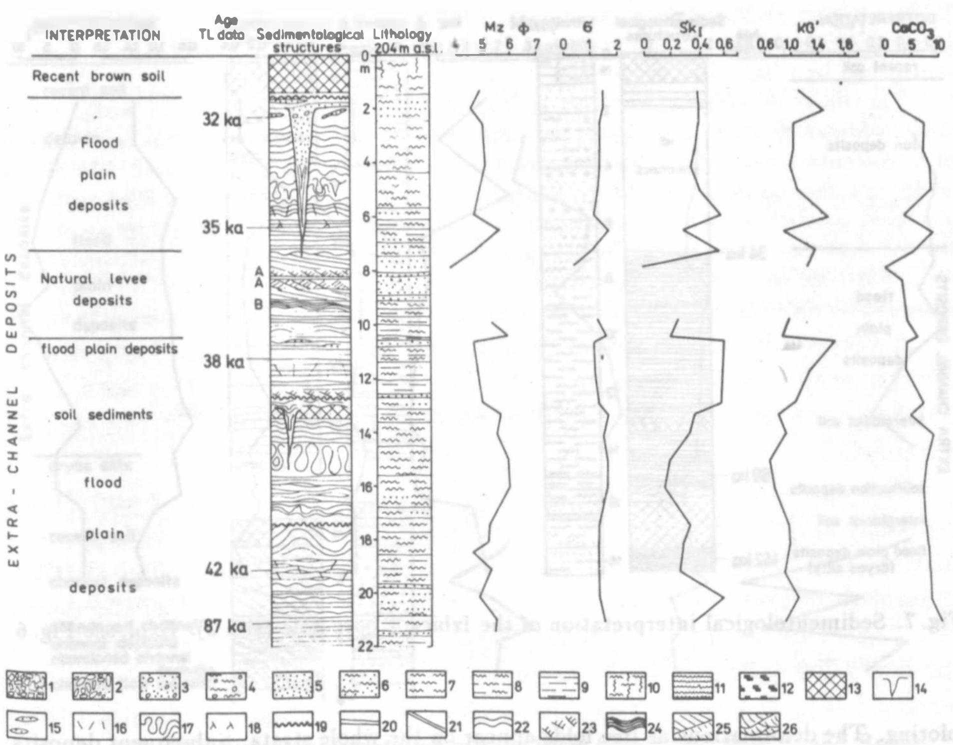

Fig. 6. Sedimentological interpretation of the Latyczów outcrop (site 1)
1 — debris-gravel cover; 2 — gravels; 3 — sands with gravels; 4 — loams with gravels; 5 — sands; 6 — loamy sands; 7 — loams; 8 — clay loams, 9 — clays; 10 — loesses; 11 — organic muds; 12 — peats; 13 — fossil soil; 14 — pseudomorphosis of ice wedges; 15 — pseudomorphosis of ice layers; 16 — dessication fissures; 17 — strongly deformed laminations; 18 — roots traces; 19 — erosional contact; 20 — horizontal lamination; 21 — subhorizontal lamination; 22 — sinusoidal waves lamination; 23 — A type ripples; 24 — B type ripples; 25 — tabular cross lamination; 26 — through cross lamination. TL data from Laboratory of Physical Geography Department, University of Maria Curie Sklodowska in Lublin

the present mean water level in the Wieprz. This fact was stressed by A. Jahn (1956). As a result, the Latyczów profile (Fig. 5) situated just in the northern part of the gap, represents the whole profile of Vistulian deposits.

Beginning from the floor (19.8-22.1 m) these are steel-grey or greenish silts with lamines of very fine sands. The sands lamines are 1-3 mm thick, slightly thicker than the silt lamines. The lamines form some clear sets with thickness of 10-15 cm. Some disturbations of micro folds nature in 2-3 neighbouring lamines were observed. Grey-beige silts, streak-stratified and laminated, with single streaks of fine sand, are found above. The stratification is disturbed, especially in the top part where there are numerous cracks ranging vertically to 20 cm. Grey and pale brown stratified silty clays (17.7-18.5 m) occur above these deposits. Particular streaks are 3-5 mm thick and differ with respect to

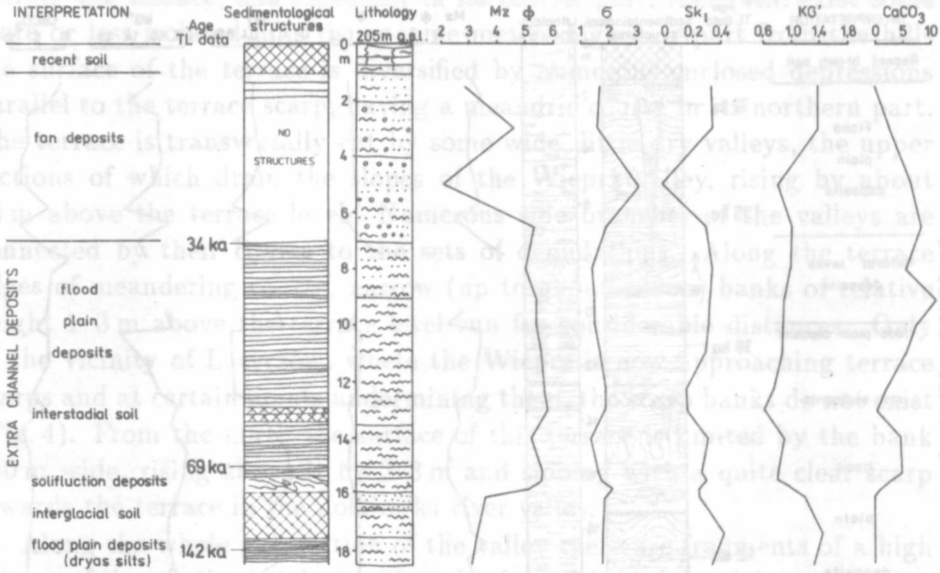

Fig. 7. Sedimentological interpretation of the Izbica 1 bore hole (site 2). Expl. see Fig. 6

coloring. The deformations as free folds appear on the whole strata. Subsequent deposits (15.6–17.7 m) are grey and pale-grey silts, laminated or streak stratified, slightly sandy at places, markedly more clayey at the top.

The next layer 1.1 m thick consists of grey yellowish and pale-grey silts, characterized by very strong deformation of stratification. These deposits are almost identical with the top part of the next layer, with respect to granulation parameters. Above, (13.6–14.5 m) there still occur silts, sinusoidal stratified and of varying coloring: dark grey, grey-beige to brown. The whole of the series described above is characterized by the carbonate content from about 10% in the floor to about 7% in the middle part and 9% at the top (Fig. 6). The complex of described silt deposits is wreathed by the layers of dark grey and grey-brown silts, slightly clayey ones, 0.5 m thick, of very numerous manganese concretions. At this layers, the $CaCO_3$ content decreases (up to 4.5% in Latyczów and 1% in Izbica 1). This layer is very visible also in Tarzymiechy. It has typical features of soil sediments and is macroscopically similar to the interstadial soil in loesses deposits (H. Maruszczak 1987). This soil is cut both in Latyczów (Fig. 6) and in Tarzymiechy (J. Dylik 1956) with a wedge, 0.7 m wide at the top and deep about 2 m, filled with clayey silts of markedly flow structures. Above this soil in Latyczow there are sandy silts with lamines of grey clays up to 2 cm thick of strongly disturbed stratification. A similar arrangement of layers was recorded by J. Dylik (1956) in Tarzymiechy. These layers are truncated by fine sands with ripplemarks, passing into the silts of sinusoidal and lenticular stratification. The sand layer is only 15 cm thick in Latyczow (12.55–12.7 m). It is slightly thicker in Tarzymiechy (to 0.4m), yet in the Izbica 1 bore (Fig. 7) situated further from the valley axis sandy layers are not present. There are only silts over the soil in this borehole. These silts are much characterized by constant increase in $CaCO_3$ content above the interstadial soil (from 2.4% at the depth of 12.3 m to 11% at the depth of 9 m).

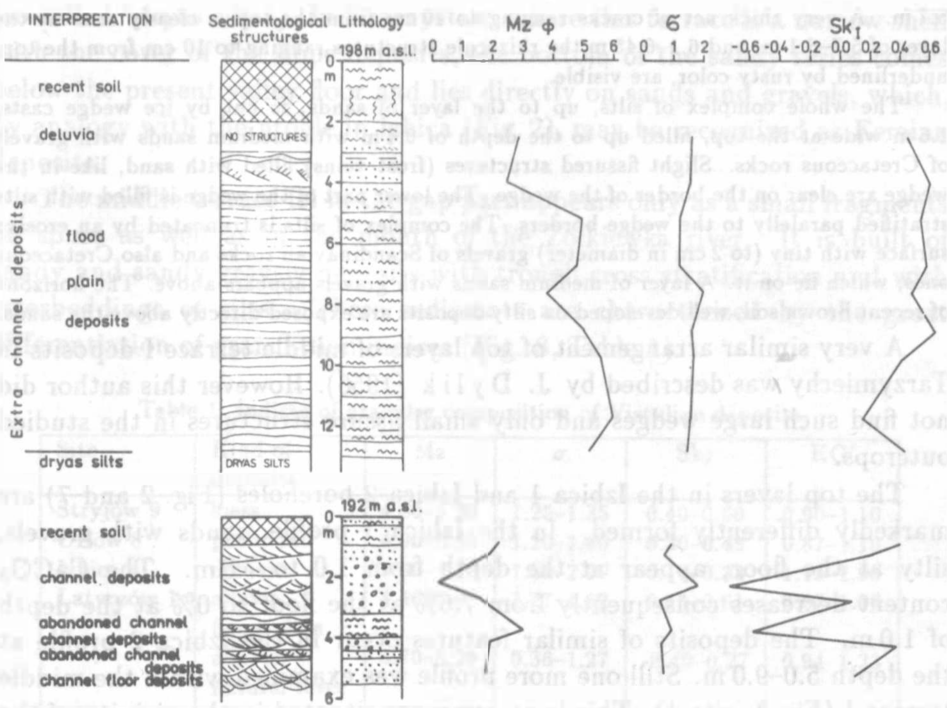

Fig. 8. Sedimentological interpretation of the Orlów 6 bore hole (site 6) and Rońsko outcrop (site 7). Explanation see Fig. 6

Above the sands of the Latyczów profile, at the layer of 10.8–12.55 m, there are grey-yellowish silts with pale-steel interbeddings with rusty streaks. The thickness of some interbeddings lenses toward the top decreases from about 50 cm to 10–15 cm. The top of silty interbeddings clearly show parallel stratification with the dips about 5° towards the south. Very characteristic set occurs above: 0.3 m silty sands, lentically stratified and 0.15 m of pale, structureless loams. Then clayey silts (8.9–10.35 m) appear in the profile, they are sandy, laminated and irregularly streaked at the top. The top layer (9:0–9.3 m) shows the lenses of white fine sand, the thickness of which reaches 3 cm and the strike 10–15 cm. At the top of this layer there are single gravels of decalcified opoka (local rocks) to 6 mm in diameter.

Then fine sands (7.45–8.9 m), very well sorted (Fig. 6) occur there. Oblique stratifications of small scale ripplemarks A type or subordinately type B (J. Allen 1968, 1970) occur there, and also horizontal and subhorizontal stratifications with 5° dips towards S and SW. In these sands layer dominated the fraction 0.1–0.05 mm (85%), with only 3% silt. The first centyle is 2.35 phi in diameter.

Above these sands a differentiated complex of sandy silts appears again (2.45–7.45 m). These are sandy silts or clayey ones sinusoidal or horizontally stratified. A slight tendency of decrease of the mean diameter towards the top (Fig. 6) appears in the granulation of these deposits. The differentiation of this complex also shows in the degree of the stratification disturbance. The greatest disturbances appear also at the layer of 4.3–

5.7 m. A very thick net of cracks ranging to 10 cm from the top is clearly seen at the layer of 5.7–6.1 m, and 6.1–6.45 m the rhizocole structures ranging to 10 cm from the top, underlined by rusty color, are visible.

The whole complex of silts, up to the layer of sands, is cut by ice wedge casts, 1.6 m wide at the top, filled up to the depth of 0.4 m with medium sands with gravels of Cretaceous rocks. Slight fissured structures (frost veins) filled with sand, like in the wedge are clear on the border of the wedge. The lower part of the wedge is filled with silts stratified paralelly to the wedge borders. The complex of silts is truncated by an erosive surface with tiny (to 2 cm in diameter) gravels of Scandinavian rocks and also Cretaceous ones, which lie on it. A layer of medium sands with gravels appears above. The horizons of recent brown soil, well developed on silty deposits are exposed directly above the sands.

A very similar arrangement of top layers of middle terrace I deposits in Tarzymiechy was described by J. Dylik (1956). However this author did not find such large wedges and only small fissure structures in the studied outcrops.

The top layers in the Izbica 1 and Izbica 2 boreholes (Fig. 2 and 7) are markedly differently formed. In the Izbica 1 profile, sands with gravels, silty at the floor, appear at the depth from 1.0 to 7.0 m. The $CaCO_3$ content decreases consequently from 7.6% at the floor to 0% at the depth of 1.0 m. The deposits of similar features occur in the Izbica 2 profile at the depth 5.0–9.0 m. Still one more profile was examined within the middle terrace I (Fig. 1, site 4). This is an exposure situated in the vicinity of the Wieprz valley slope. The deposits 11.0 m thick occurring on the Cretaceous rocks are exposed here. These are structureless sands from the floor to the depth of 9.0 m. Towards the top, they change into silty sands, horizontally stratified with the streaks of fine sand. At the depth of 5.4–7.0 m there appear sands and silts with 2–8° dips towards E and NE. These deposits are covered by loamy sands (grey and rusty) of clear flow structure (4.2–5.4 m). At the top of the exposure there appear medium sands and silty sands, irregularly stratified and streaked of the layer dips 10° towards NE. Almost the whole profile can be interpreted as slope deposits intercalated with fluvial sediments on the bottom part.

THE GEOLOGICAL STRUCTURE OF MIDLLE TERRACE II AND MIDDLE TERRACE III

The degree of examining the structure of the middle terrace II is much worse, it lacks greater exposures. Only a few archival hydrogeological drillings allow the claim that they are mainly formed of sandy deposits with numerous interbeddings of sands with gravels, mainly of Upper Cretaceous rocks. Also silty-sandy interbeddings several centimeter thick occur there. Below the sandy series 10–15 m thick there appear typical dark grey silts (so called "dryas silts"). In Krasnystaw, where this terrace is a narrow shelf with the cover of the slope deposits, the bottom of the sandy series comes below the present valley floor and lies directly on sands and gravels, which, by analogy with the profile in Izbica (Fig. 2), may be recognized as Eemian deposits.

The middle terrace III in the gap part appears only as a small fragments on spurs as well as in the mouth of the Żółkiewka river. It is built of sandy and sandy gravely deposits with trough cross stratification and with interbeddings of silts. These sediments are characterized by the great differentiation of granulation indices (Fig. 8, Table 1).

Table 1. Indices of granular composition of Vistulian deposits

Site	Kind of deposits	Mz	σ	Sk_I	KG'
Stryjów 9	loess	4.80–5.20	1.25–1.35	0.40–0.60	0.90–1.10
Orłow 8	proluvia	4.90–5.60	1.20–1.80	0.30–0.48	0.87–1.10
Izbica 4	deluvia	3.00–4.20	1.50–2.00	0.14–0.33	1.19–1.96
Latyczów 1	alluvia flood plain	4.46–5.96	1.27–1.62	0.15–0.61	0.67–1.06
	alluvia natural levee	3.70–5.29	0.36–1.27	-0.40–0.27	0.94–1.23
Izbica 2	alluvia flood plain	5.25–5.78	1.36–1.89	0.15–0.32	0.62–0.92
	fan deposits	2.15–5.37	1.40–3.07	-0.02–0.34	0.72–1.37
Rońsko 7	channel	0.21–2.21	0.54–1.81	-0.76–0.40	0.72–1.74
	abandoned channel	1.92–3.01	0.60–0.93	-0.57–0.37	1.65–1.74

THE DEVELOPMENT OF THE WIEPRZ VALLEY DURING VISTULIAN

The problem of sedimentation conditions of the middle terrace I deposits was discussed by A. Jahn (1956) and J. Dylik (1956) and later — on the basis of the interpretation of the materials presented by these authors — by J. Jersak (1976). As it was mentioned above, there is a basic difference in views on the age of the whole deposits complex exposed in Tarzymiechy. J. Dylik's (1956) claim concerning the Middle Polish glaciation age of the whole complex of the middle terrace I deposits in view of the presented results is not to be retained. Still, Dylik's considerations concerning the conditions, under which sedimentation took place, are extremely valuable. Both J. Dylik (1956), A. Jahn (1956) and J. Jersak (1976) generally agree as to the assumption that these are fluvial and lacustrine deposits

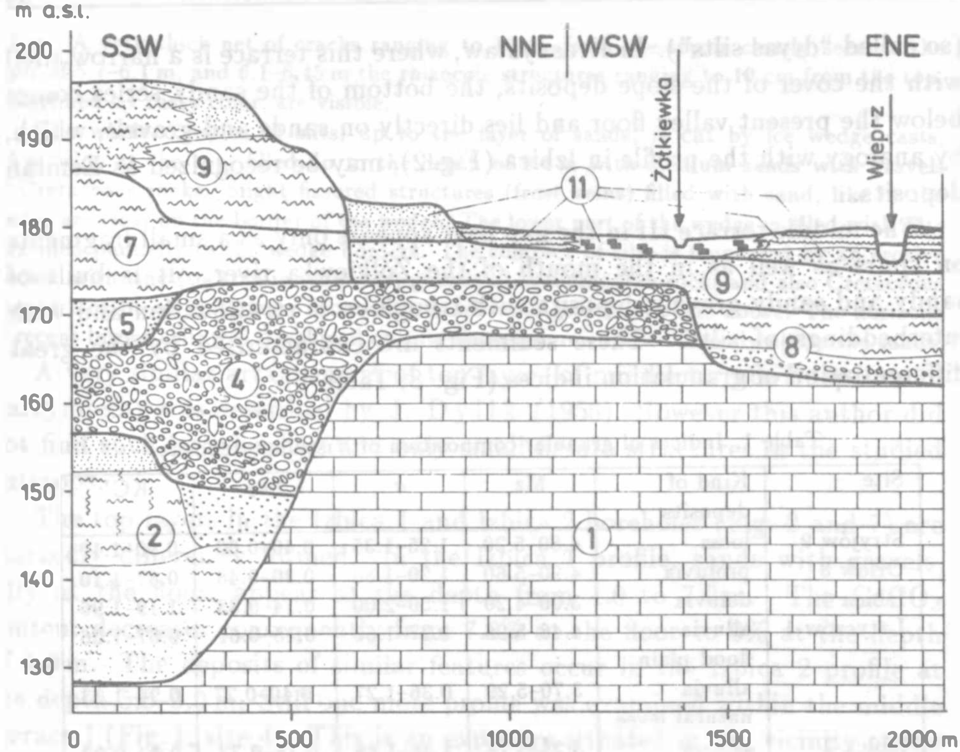

Fig. 9. Geological cross section of axis part of the Wieprz valley southward from the Żółkiewka River mouth. Explanation see Fig. 2 and 6

of periglacial environment with a clear share of eolian component. A. J a h n (1956) stresses still a great role of the slope processes in the terrace formation. He also points at the role of valley narrowing (gap) in fluvial processes.

The middle terrace I deposits are characterized by fine granulation and the resemblance to proluvial and eolian deposits occurring in the vicinity of the valley (Fig. 10, Table 1). Sedimentation started on the surface formed with the deposits of similar character of older glaciation period. There is a lack of channel deposits at the terrace basis which under the conditions of the whole sedimentation cycle form the basis of flood facies (L. S t a r k e l 1977, S. K o z a r s k i, K. R o t n i c k i 1977, B. A n t c z a k 1986). The cause of this phenomenon was probably the "confinement" of the Eemian Wieprz bed in a quite narrow zone of the course forced partially by the fans of tributary valleys. The intensive accumulation on the wide valley bottom could start only when valley cut in interglacial time was shallowed to such a degree that the flood waves could already extend over its limits.

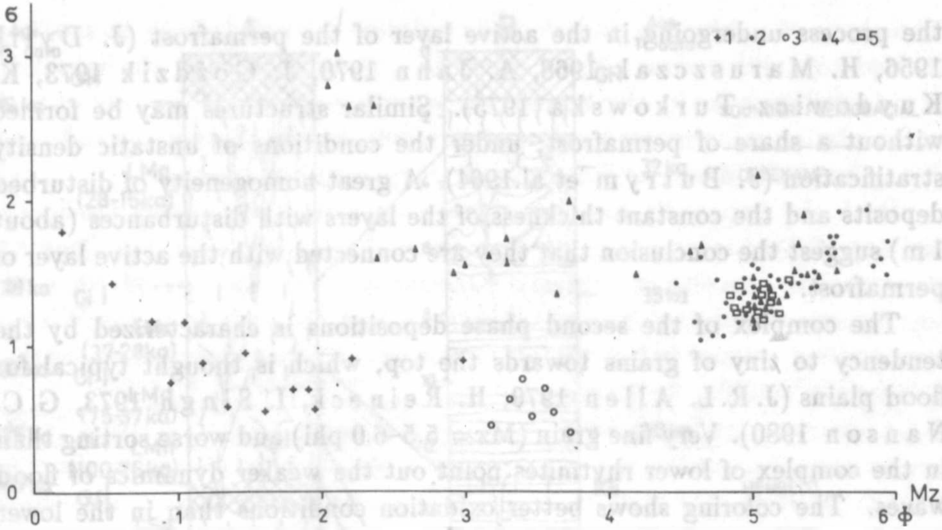

Fig. 10. Listing values of standard deviation (σ) and mean diameter (Mz) in ø scale of Vistulian deposits from the Wieprz valley

1 — channel deposits; 2 — flood plain deposits; 3 — natural levee deposits; 4 — slope deposits (proluvia and deluvia from site 8); 5 — loess (site nr 9)

The bottom series of Vistulian deposits is formed by typical rhytmites found lately as a good indicator of the changeability of flood water hydrological regime (D. Walling, B. Webb 1983, V. R. Baker 1983, B. Antczak 1985, 1986). Both the thickness of rhytmites sets (10–15 cm) and particular lamines (1–3 mm) are much smaller than the ones described by B. Antczak (1985) from the Warta valley. It evidences comparatively low flood dynamics. Also mean diameters of grains in a rhytmite complex (0.02–0.07 mm) indicate very weak currents. The first centile of these deposits (3.3–3.6 phi) allows for approximate estimation of water velocity below 10 cm sec^{-1}. Grey-greenish coloring of the deposits points out strong humidity of the flood plain and the tendency to gleyfication.

In the first phase the accumulation of the extra-bed deposits cover was very slow — during 40 ka the flood plain was built on by only about 2 m (on the average about 0.05 mm per year). This period corresponds to the accumulation of the lowest and lower younger loess on interfluve (LMn and LMd according to H. Maruszczak 1987). The complex of silt deposits of grey, greybeige and grey-yellowish coloring, with sandy lamines, was accumulated in the second phase. Within them there is a clear level of truncation as well as the disturbations of involution type. These are treated as a periglacial climate indices and they are genetically connected with the process undergoing in the active layer of the permafrost (J. Dylik 1956, H. Maruszczak 1968, A. Jahn 1970, J. Goździk 1973, K. Kuydowicz-Turkowska 1975). Similar structures may be formed without a share of permafrost, under the conditions of unstatic density stratification (J. Butrym et al.1964). A great homogeneity of disturbed deposits and the constant thickness of the layers with disturbances (about 1 m) suggest the conclusion that they are connected with the active layer of permafrost.

The complex of the second phase depositions is characterized by the tendency to tiny of grains towards the top, which is thought typical for flood plains (J.R.L. Allen 1970, H. Reineck, I. Singh 1973, G.C. Nanson 1980). Very fine grain (Mz = 5.5–6.0 phi) and worse sorting than in the complex of lower rhytmites point out the weaker dynamics of flood waves. The coloring shows better oxidation conditions than in the lower complex. This may be however, a secondary feature.

The rhytmite complex and overlaying silt deposits may be spatially related to the mesoenvironment of flood plain as understood by A. Teisseyre (1988), or with the area of flood plain (D. Gonera et al. 1985, Z. Zwoliński 1985). On these deposits is developed interstadial soil comprising about 0.6% of humus. It proves a break in sedimentation or decreasing vertical reach of flood or marked decrease of their frequency about the interval 37–39 ka BP. This soil, according to the TL dating, may be correlated with Hengelo interstadial (Fig. 11). The soil is cut with ice wedge casts structures.

Above the fossil soil there occurs a complex of fine sand and silty sand deposits, which J. Dylik (1956) and A. Jahn (1956) interpreted as channel deposits. They are characterized by ripplemark or horizontal stratification. Dips, showing the transversal or oblique flows in relation to the valley axis, were most often reported there. This complex may be interpreted as the deposits of the group of natural levee mesoenvironments (A. Teisseyre 1988). An intensive drift deposition in this area is strictly connected with violent changes of water transportation competence in the phase of bed overflowing (H.N. Fisk 1944, L.B. Leopold et al. 1964, J. Allen 1970). Then the way of material transportation changes from the suspension in the bed to dragging and saltation in the river bed side (K. Klimek 1972, Z. Zwoliński 1985).

The upper silt complex in Latyczów again represents the mesoenvironment of flood plain. Fossil root traces, slight fissures, structures connected with electrophoresis indicate to longest period without floods, and plain being occupied by plants. The presence of structures connected with per-

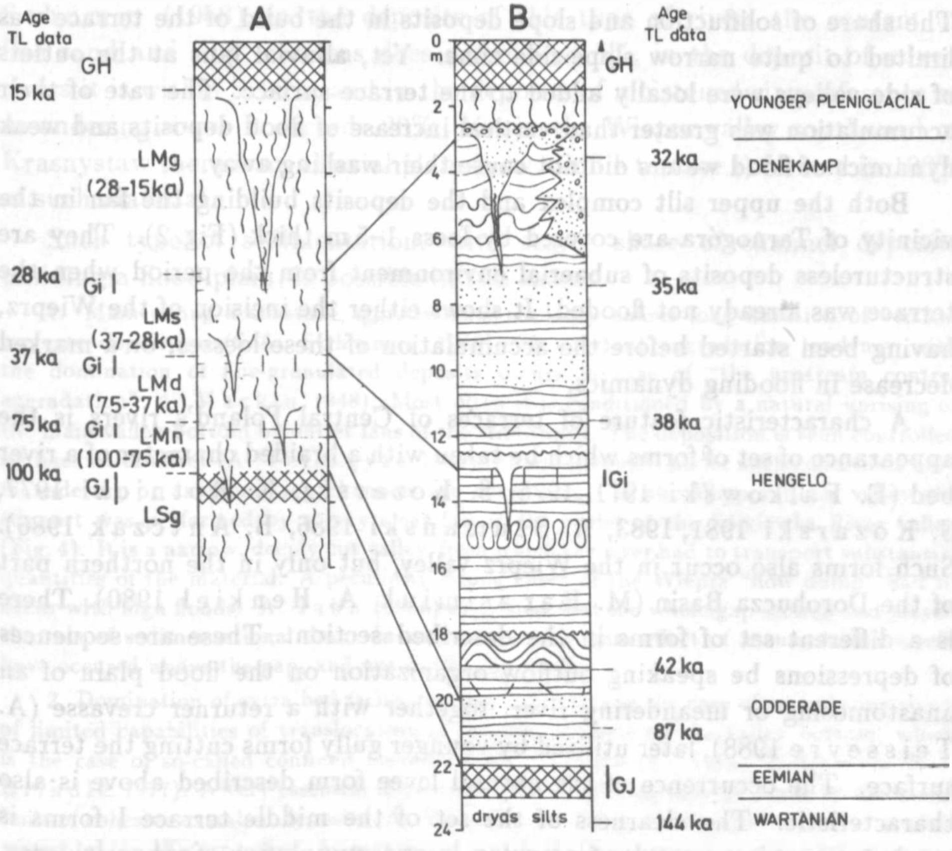

Fig. 11. Correlation of loess accumulation phases on the Lublin Upland (A) after H. Maruszczak (1987) with stratigraphical scheme of Vistulian alluvial deposits from the Wieprz valley (B)

Letters symbols: LM — younger loesses; n — lowest, d — lower, s — middle, g — upper; GJ — interglacial soil; Gi — interstadial soil; GH — Holocene soil

mafrost (involution, large ice wedges casts) indicates on sedimentation in periglacial conditions. This complex was deposited during the period of about 3 ka, which gives a mean accumulation rate of more than 1 mm per year.

The upper silt complex is truncated and covered by a discontinuous layer of medium-grained sands with gravels, wrongly sorted and not stratified. They may represent the deposit of slope waters overflowing the terrace which was already beyond the reach of flood.

The analysis of the whole middle terrace I deposits shows that we deal here with a huge series of flood deposits of the river with fairly stable bed.

The share of solifluction and slope deposits in the build of the terrace was limited to quite narrow slope-side zone. Yet, alluvial fans at the outlets of side valleys were locally added to the terrace surface. The rate of their accumulation was greater than vertical increase of flood deposits and weak dynamics of flood waters did not cause their washing away.

Both the upper silt complex and the deposits building the fan in the vicinity of Tarnogóra are covered by loess 1–5 m thick (Fig. 2). They are structureless deposits of subaerial environment from the period when the terrace was already not flooded. It shows either the incision of the Wieprz, having been started before the accumulation of these loesses, or a marked decrease in flooding dynamics.

A characteristic feature of terraces of Central Poland's rivers is the appearance of set of forms which be taken with a braided character of a river bed (E. Falkowski 1971, 1975, S. Kozarski, K. Rotnicki 1977, S. Kozarski 1981, 1983, A. Szumański 1986, B. Antczak 1986). Such forms also occur in the Wieprz valley, but only in the northern part of the Dorohucza Basin (M. Harasimiuk A. Henkiel 1980). There is a different set of forms in the described section. These are sequences of depressions be speaking outflow organization on the flood plain of an anastomosing or meandering river, together with a returner crevasse (A. Teisseyre 1988), later utilized by younger gully forms cutting the terrace surface. The occurrence of the natural levee form described above is also characteristic. The clearness of the set of the middle terrace I forms is much decreased as a result of irregular, later accumulation of subaerial loess. Increased loess thickness is observed on the fragments of preserved natural levee forms.

What are the reasons for such individual development of the middle Wieprz valley bottom in the Vistulian? During the most part of the Vistulian there prevailed sporadic and discontinuous permafrost; only in the upper pleniglacial the development of continuous permafrost took place (H. Maruszczak 1968, 1987). During this period the rivers in Poland had an subarctic nival regime according to M. Church's (1972) classification, with a prevailing bed type of braided development (L. Starkel 1977, 1983, S. Kozarski 1983). A characteristic feature of such rivers according to S. A. Schumm (1960, 1977) is their sinuosity below 1.25 and dominance of bottom load. This type of river beds function well with great flow velocity, with great changeability of water levels and transported material. The sedimentation of material transported in suspension most often does not take place in a braided river valleys. The most part is carried beyond the extent of a braided section (A. Teisseyre 1988). According to S. A.

Schumm (1968), in the deposits of this type of rivers the content of fine sand and silty fractions does not exceed 5%, in the deposit of mixed rivers it is within 5–20%, and in the deposits of moistened circumference of meandering rivers it exceeds 20%. Yet in the Wieprz valley southward of Krasnystaw there is an alluvial plain (now middle terrace I) formed in 100% of such material.

Such type of sedimentation, with scarce share of channel deposits building a flood plain, is possible in two cases:

1. Maintaining a constant aggradational tendency causes long duration of vertical increase deposition (S. A. Schumm 1960). A constant aggradation tendency with the domination of fine-granulated deposits occurs in case of "the upstream control aggradation" A. Mackin 1948). Most often it is conditioned by a natural uprising of the main valley bottom by outlet fans of the tributaries. The deposition is then controlled by backwater effect (A. Teisseyre 1988). Simultaneously, under such conditions only meandering or anastomosing channels are developing. In the Wieprz River valley the support was performed by a very clear fan at the outlet of the Żółkiewka River valley (Fig. 4). It is a narrow, deeply cut valley, from which the river had to transport substantial quantities of the material. A peculiarly strong effect of the Wieprz "flow dump" had to occur with high floods. A. Jahn (1956) suggested that the whole gap section had played the role of sedimentational dam. In such a case the main effect of accumulation would have occured above the gap, and not in the gap itself.

2. Domination of extra bed facies can also take place in the case of meandering rivers of limited capabilities of translocation of meandering belt on the valley bottom, which is the case of so-called confined meanders (E. Falkowski 1975, J. Lewin, B. J. Brindle 1977). A very essential impediment of meandering may be made by the banks built of cohesive extrabed deposits (A. Teisseyre 1988). Such a case occurs at studied section of the Wieprz valley. As mentioned above, the confinement of a bed translocation area on the valley bottom has appeared since the period of interglacial icision into the silt deposits of the Warta glaciation. At the same time it must be stated that about 30% of the Wieprz River basin up Krasnystaw is covered by loesses. With large denivelation it exercised the supply of vast quantities of suspension material to the bed, especially in the same gap section. Many factors forced therefore and strengthened the deposition character at the Wieprz gap section. These were the factors indirectly connected to the periglacial climatic conditions. However, these did not play a decisive role. More important were local factors which provided an extremely great supply of fine-grained material, and also impeded the flow of high flood waves, characteristic for the rivers of a periglacial zone (L. Arnborg et al.1967, A. Jahn 1970).

The changes of a riverbed configuration and also the type of an alluvial plain occur slowly up to the moment of reaching threshold values (L. B. Leopold, M. G. Wolman 1957, E. W. Lane 1957, S. A. Schumm 1977). Such threshold situation is described by the equation: $S=0.014Q^{-0.44}$. This equation leads to the conclusion that the balance unsettling may be conditioned either by climatic changes (Q value) or by the change of the slope of river bed (as the result of unequal accumulation in a longitudinal profile or tectonic movements). S. Kozarski (1983),

A. Szumański (1986), B. Antczak (1986) and others proved that the occurence of threshold situations and also riverbed transformations as well as alluvial plains on the area of Poland was mainly connected with climatic conditions. This was both a direct effect (the flow change and their equalization) and also indirect (the change in vegetation, the limitation of material supply to the riverbed), of climatic changes occurring on wide area.

Yet, supporting of the valley by fan and the development of aggradational processes guided upwards caused the gradual increase of a slope of bed in a short section. When the slope approaches the threshold value, even one great flood may be a catalyzer of sudden changes in the valley. The effect of such changes may be setting violent erosion, up to the destruction of the alluvial plain (C.T. Nadler, S.A. Schumm 1981, A. Teisseyre 1988). The facts presented above show, that such a phenomenon may have taken place in a studied section of the Wieprz valley.

The effects resulting from the changes of autigenic character (J. Lewin, B.J. Brindle 1977), which are the consequence of the evolution of the riverbed-alluvial plain system, could be superimposed by the allogenic changes conditioned by climatic factors. The main phase of alluviation in the Wieprz valley occured in the interpleniglacial (Fig. 12). Such a statement stands in partial opposition with L. Starkel's (1977) conclusion about the predominance of erosion processes in the river valleys on the Carpathian foreland in that period.

Most authors studying alluvial processes in Poland claim that the beginning of riverbed transformation took place in the Bölling interstadial (S. Kozarski 1983, S. Kozarski, K. Rotnicki 1977 L. Starkel 1977, 1983, B. Antczak 1986). Lately, however A. Szumański (1986) has pointed out that the first phase of cutting in the San valley alluvial plain in the Sandomierz Basin took place still before the oldest Dryas. In the discussed section of the middle Wieprz valley it occured about 28 ka BP (on the turn of the interpleniglacial and the younger pleniglacial).

As a result of the processes of accelerated cutting of the river bed, the terrace — originally often flooded — was found beyond the reach of flood waves of the Wieprz. On its surface spatially differentiated accumulation of loess dust (M.Harasimiuk 1987) and the development of younger erosive-denudative forms connected with concentrated water flow from the slope could begin. The development of these forms reverted to mesorelief of the alluvial plane surface shaped by flood processes.

A. Jahn (1956) claims, that this intensified loess accumulation in some narrow transversal zones in relation to the valley (Izbica — Tarnogóra. Krasnystaw) caused the rising of the valley bottom and its barricading. In

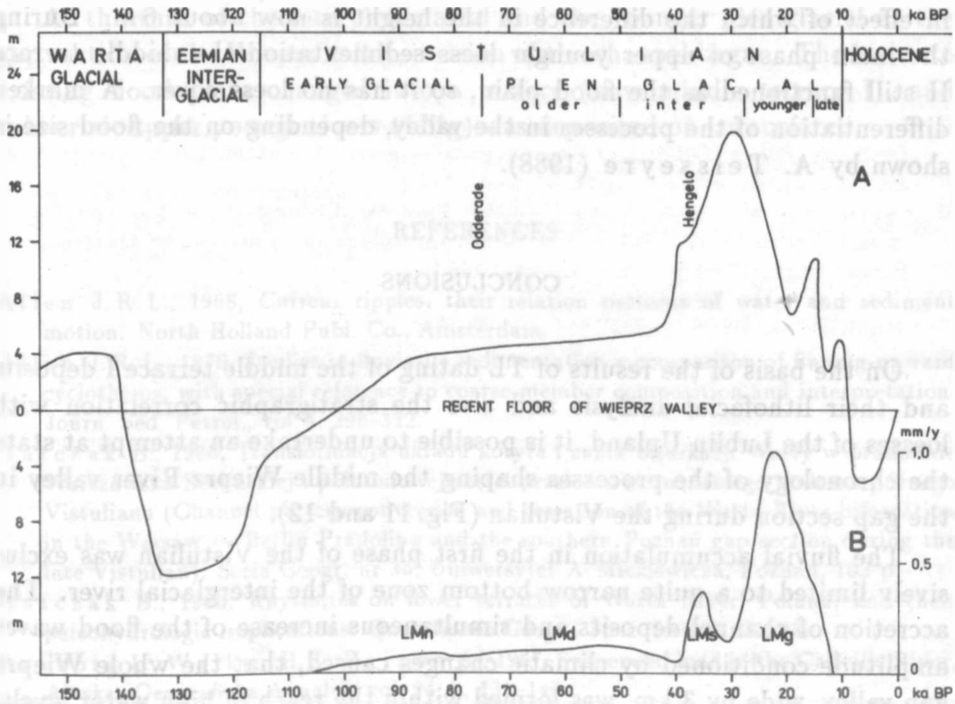

Fig. 12. Reconstruction of the Wieprz valley floor situation compared with recent floor valley as a rate of fluvial processes in Vistulian (A) and mean rate of the younger loess accumulation in Poland after H. Maruszczak, 1987 (B)

the light of presented facts it can be stated, that the fans of side valleys barricaded the valley, and the loess accumulation occured on the older convex elements of the valley bottom sculpture (natural levee, fans), which were found beyond the reach of flood waves.

An interesting issue is the problem of middle terrace I and terrace II relations. As it was mentioned above, A. Jahn (1956) claimed that the hipsometric differentiation results from a heterogeneous share of slope deposits in their structure and is the effect of cutting the surface of original concave character. I fully agree with A. Jahn (1956), that these are coeval surfaces, but they are formed by a different processes. The middle terrace II was formed mainly by riverbed processes of an anastomosing or anastomosing-braided river, and by low flood waves (a slight share of clayey-sandy facies of the vertical accretion). Yet the middle terrace I was formed only by high flood waves. The original difference in the height of these surfaces could be of about 3 m. The middle terrace I was covered by a loess, in effect of which the difference in the height is now about 6 m. During the main phase of upper younger loess sedimentation the middle terrace II still functioned as the flood plain, so it has no loess cover. A marked differentiation of the processes in the valley, depending on the flood size is shown by A. Teisseyre (1988).

CONCLUSIONS

On the basis of the results of TL dating of the middle terrace I deposits and their lithofacial analysis and also the stratigraphic correlation with loesses of the Lublin Upland, it is possible to undertake an attempt at state the chronology of the processes shaping the middle Wieprz River valley in the gap section during the Vistulian (Fig. 11 and 12).

The fluvial accumulation in the first phase of the Vistulian was exclusively limited to a quite narrow bottom zone of the interglacial river. The accretion of channel deposits and simultaneous increase of the flood waves amplitude conditioned by climatic changes caused, that the whole Wieprz gap valley, wide by 3 km, was formed within the reach of high water levels. This process was not simultaneous in the whole cross sections, as it is indicated by the age of Vistulian floor deposits in Latyczów — 87 ka BP (Fig. 6) and in Izbica — 69 ka BP (Fig. 7).

The first sedimentation period of the flood deposits on the valley bottom corresponded to the lowest younger loess accumulation (H. Maruszczak 1987). This period corresponds to the early Vistulian period EV 3 *Graminae — Artemisia — Betula nana* R PAZ phase (K. Mamakowa 1986).

The older pleniglacial is a period of lower younger loess sedimentation (H. Maruszczak 1987) and the sedimentation of the sheet of fine-grained (homogeneous suspension) flood deposits in the valley, with a marked tendency towards the accumulation increase rate with the late stage of this period. The steppe tundra conditions prevailed then (EV 5 *Graminae — Betula nana* R PAZ, according to K. Mamakowa 1985). Interstadial soil, which may be correlated on the basis of the TL dating with Hengelo interstadial (marked warming up within the interpleniglacial), was developed on these deposits. Soil development under the conditions of alluvial plain clearly show the deterioration or strong limitation of flood frequency. The following stage, this time of clearly accelerated alluvial accumulation may be correlated with middle younger loess sedimentation. The flood plain surface reached an absolute height of 195–197 m a.s.l. at that time.

At the turn of the interpleniglacial and the younger pleniglacial at the gap section of the Wieprz valley, incision of the channel began. The hitherto existing flood plain changed into a terrace (now middle terrace I), and subaerial, upper younger loess (LMg) was deposited on its surface.

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STRESZCZENIE

Badania przeprowadzono w przełomowej dolinie Wieprza na południe od Krasnegostawu. Jest to 16 km długości odcinek doliny o założeniach strukturalnych łączący Kotlinę Zamojską z Obniżeniem Dorohuckim. W badanej części doliny wyróżniono system teras nadzalewowych: wysoka (24-28 m) — datowana na zlodowacenie Odry; średnie (I. 18-24 m, II. 15-16 m, III. 9-13 m) datowane na zlodowacenie Wisły, oraz niskie (I. 3-5 m i II. 2,5-3,5 m) — holoceńskie. Równia zalewowa ma wysokość 1,5-2 m ponad średni poziom wody w korycie, a jej szerokość waha się w granicach od 300 do 1500 m. Największą powierzchnię spośród wyróżnionych teras nadzalewowych zajmuje terasa średnia I, której szerokość w odcinku południowym przełomu dochodzi do 1,5 km, a w północnym (po zachodniej stronie doliny) nawet do 2 km. Charakteryzuje ją prawie stała wysokość bezwzględna na całej długości przełomu (około 200 m). Rzeźbę tej terasy urozmaicają zagłębienia bezodpływowe o zakolowym przebiegu, a także — w pobliżu krawędzi terasy — wały brzegowe o wysokości względnej do 3 m i szerokości dochodzącej do 100 m.

Budowę geologiczną terasy średniej I rozpoznano szczegółowo dzięki trzem dużym odsłonięciom oraz trzem rdzeniowanym wierceniom. Przestrzenne zróżnicowanie utworów budujących tę terasę jest niewielkie; również zmienność w profilach pionowych jest mała, co pozwala na dobre korelowanie poszczególnych odsłonięć i wierceń. We wszystkich badanych punktach cokół terasy zbudowany jest z mułków dryasowych datowanych na zlodowacenie Warty. Na mułkach tych miejscami zachowana jest dobrze rozwinięta gleba interglacjalna. W budowie terasy zdecydowanie dominują utwory mułkowe i mułkowo ilaste; podrzędnie występują piaski mułkowate i piaski drobnoziarniste. Mimo pozornej monotonności tych utworów można wśród nich wyróżnić kilka kompleksów (cykli) sedymentacyjnych. Spągową serię stanowią typowe rytmity o miąższości lamin do 3 mm w zestawach 10-15 cm miąższości. Średnie średnice ziarn mułków z tego kompleksu zawarte są w granicach 0,02-0,07 mm, co wskazuje na bardzo słabe prądy. Szarozielonkawe zabarwienie osadów świadczy o silnym uwilgoceniu równi zalewowej na powierzchni której były one osadzane, a także o tendencji do oglejenia. W drugiej fazie sedymentacji osadzony został kompleks mułków szarobeżowych i szarożółtawych z laminami piaszczystymi. W ich obrębie występują zaburzenia typu inwolucji oraz powierzchnie ścięć erozyjnych. Ten kompleks osadów cechuje się tendencją do zmniejszania się średniej średnicy ziarn

ku górze, ogólnie drobniejszym ziarnem i gorszym wysortowaniem w stosunku do kompleksu podległego. Obydwa kompleksy reprezentują mezośrodowisko równi zalewowej, a zróżnicowanie ich cech wynika z różnej dynamiki fal powodziowych.

Na osadach kompleksu drugiego rozwinięta jest gleba interstadialna świadcząca o przerwie w procesach sedymentacyjnych, czyli o zmniejszeniu zasięgu pionowego powodzi. Na podstawie datowań TL glebę tą można korelować z interstadiałem Hengelo. Nad glebą kopalną występują osady drobnopiaszczyste i pylasto-piaszczyste reprezentujące mezośrodowisko naturalnego wału brzegowego.

Kolejny kompleks o miąższości około 4 m stanowią ponownie mułki reprezentujące mezośrodowisko równi zalewowej. Występują w nich zaburzenia typu inwolucji, a także pseudomorfozy klinów zmarzlinowych. Utwory tego kompleksu osadzone zostały w przedziale czasowym 35–32 ka BP, co odpowiada fazie sedymentacji lessów młodszych środkowych (LMs) według H. M a r u s z c z a k a (1987). Ten górny kompleks mułków ścięty jest erozyjnie i przykryty nieciągłą warstwą piasków średnioziarnistych, reprezentujących osad wód spływających ze zboczy doliny. Strop osadów budujących terasę średnią I tworzą lessy typowe o miąższości dochodzącej do 5 m, świadczące o środowisku subaeralnym. Powierzchnia terasy nie była już wówczas zalewana podczas powodzi.

Analiza facjalna utworów budujących terasę średnią I wskazuje, że stanowią one potężną serię osadów powodziowych. Zdecydowana dominacja facji powodziowych w budowie równi zalewowej w pełni rozwiniętej jest możliwa w dwu przypadkach: 1) występowanie "agradacji sterowanej od dołu" — depozycja jest wówczas kontrolowana przez efekt piętrzenia (J.H.Mackin 1948), co jest najczęściej uwarunkowane częściową blokadą doliny głównej przez stożek dopływu; 2) ograniczone możliwości przemieszczania się meandrowego po dnie doliny, czyli występowanie tak zwanych meandrów uwięzionych. Obydwie te możliwości mogły wystąpić w badanym odcinku doliny. Sedymentacja fluwialna w przełomowej dolinie Wieprza w czasie Vistulianu odbywała się w warunkach dostawy do koryta znacznych ilości materiału zawiesinowego z przyległych obszarów wierzchowinowych. Równocześnie jednak specyficzne cechy rzeźby przełomowego odcinka doliny (maksymalne zwężenie w części dolnej i stożki u wylotu dolin bocznych) utrudniały spływ wysokich fal powodziowych, a także ograniczały możliwości przemieszczania się koryta po dnie doliny. Efektem nałożenia się tych lokalnych czynników było utrzymanie się przez przeważającą część Vistulianu stabilnych warunków depozycji, ze zdecydowaną dominacją facji powodziowych.

Na przełomie interpleniglacjału i pleniglacjału młodszego w przełomowym odcinku Wieprza rozpoczęły się procesy erozyjne. Dotychczasowa równia zalewowa przekształciła się w terasę nadzalewową, a na jej powierzchni osadzały się lessy subaeralne (LMg). Miąższość najmłodszego ogniwa pokrywy lessowej jest na terasie niewielka (przeciętnie 2–3 m).