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SITES WITH ORGANIC INTERGLACIAL DEPOSITS IN THE UPPER SAN RIVER BASIN, POLISH EASTERN CARPATHIANS

INTRODUCTION

Mountain areas are accepted as "sterile" terrains with regards to sites with interglacial flora. In May 1995 T. Gerlach, when boring a high terrace in Zasław in the fork of the San and Osława valleys, reached a peat layer below a thick series of silty deposits (work done under grant no 6-P201-007-04 "Genesis and age of silty-clay deposits in the Carpathians"). In autumn 1995, L. Starkel, when investigating Quaternary deposits within the area of Lesko sheet of the Detail Geological Map of Poland, stated a series of peat and organic muds below a loam cover occurring on a high terrace of the Solinka (in Polańczyk). Samples taken from both site have been studied palinologically by K. Szczepanek (Fig. 1).

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STATE OF THE STUDIES

First detailed information about a high terrace of the San river is found in M. Klimaszewski's works (1936, 1948), who indicated the so called high terrace occurring between Lesko and Przemyśl. The terrace has a rocky socle (c. 35 m high), then gravels with the top face at 45–47 m above river level (a.r.l.), and is often covered with slope loams. Presence of erratics and glacifluvial deposits of the Cracow (Sanian) Glaciation on this level, on the middle reach of the San valley, was the basis to relate it with this period.

Geomorphological mapping of the Lesko sheet (Starkel 1960), performed in the 1950s, evidenced a common presence of the high terrace with the socle. Detail studies by J. Dziewański and L. Starkel (1961, 1962, 1967) in the region of the dams in Myczkowce and Solina allowed to determine the structure of three main Pleistocene terraces . The vastest high terrace has a socle 30–45 m a.r.l. and the top of alluvia that overlap with solifluction reaches 50–54 m (cf.

Starkel 1965). The erosional benches are cut down in the alluvia and then in the socle. Prior to covering with younger slope loams, the socle of erosional benches was weathered to 4 m. Occurrence of two various-aged series of slope deposits on the lower, Middle Polish terrace with 10–15 m high socle, suggests that the cover of the high terrace should be related to Southern Polish Glaciation. The 40–60 m high terrace where the thickness of alluvia is the largest (even to 15–20 m) forms wide valley floors (to 2–2.5 km). In these floors there are cut meandering valleys of the San river and its tributaries (Starkel 1965). That support the concept of M. Klimaszewski (1948) that the terrace should be related to the period when the Carpathian valleys were dammed up by an icesheet.

In 1963 J. Cegła described the brick-yard in Zasław and related genesis of silty-sand covers with washing down in the Late Vistulian.

The studies in the discussed terrain have not been carried out until the late 1990s. In the neighbouring valleys, however, W. Zuchiewicz (1987) has stated the presence of more numerous terrace benches with separate socles that makes one to think over not only a genetic but also age complexity of the San high terrace. When studying the profile in Humniska, located c. 25 km to NW from Zasław, at the margin of Doły Jasielsko-Sanockie, T. Gerlach et al. (1993) has shown an eolian origin of the silty-sandy covers. These findings point to a need for re-analysing the loams mantling the San high terrace. It has been evidenced by TL dating and petrographic analyses that a thick series of gravel with northern material reached to the level of the high terrace at 50–60 metres in a middle reach of the San valley, in Przemyśl region (Łanczont et al. 1988).

SITE ZASŁAW NEAR ZAGÓRZ

In the fork of the San and Osława valleys there is a broad (900 m wide) flattening at the height of c. 356 m a.s.l., that is 58 m above the San water level. Towards the San valley the flattening is dissected by two deep, basin-shaped valleys, rejuvenated by several metres deep incisions. Above the flattening, in the southward direction, a separate dome-like hill — Kicina Góra (375 m a.s.l.) with a slope gradient 5–8° rises. In west- and northward directions the flattening descends with a 40 m slope to the floors of the Osława and San valleys (304 m a.s.l.). In the eastward direction the flattening changes in a wide pass at 343 m a.s.l. where, nearby the road Zagórz–Lesko, there is the brickfield "Zasław" (Fig. 2).

According to M. Klimaszewski (1948) the discussed flattening is a fragment of the first level (high terrace) related to the Southern Polish Glaciation. It is built of 35 m high rocky socle covered with ferriginous gravel complex (12 m thick), laminated loam (3 m thick) and yellow-grey plastic loam (6 m thick). J. Cegła (1963) classified the discussed flattening to the second level (middle terrace) related to the Middle Polish Glaciation. He emphasised the twofold nature of the loam cover; in the lower part grey and blue colour prevails while light yellow in the upper part. Having no dating, he assumed them to

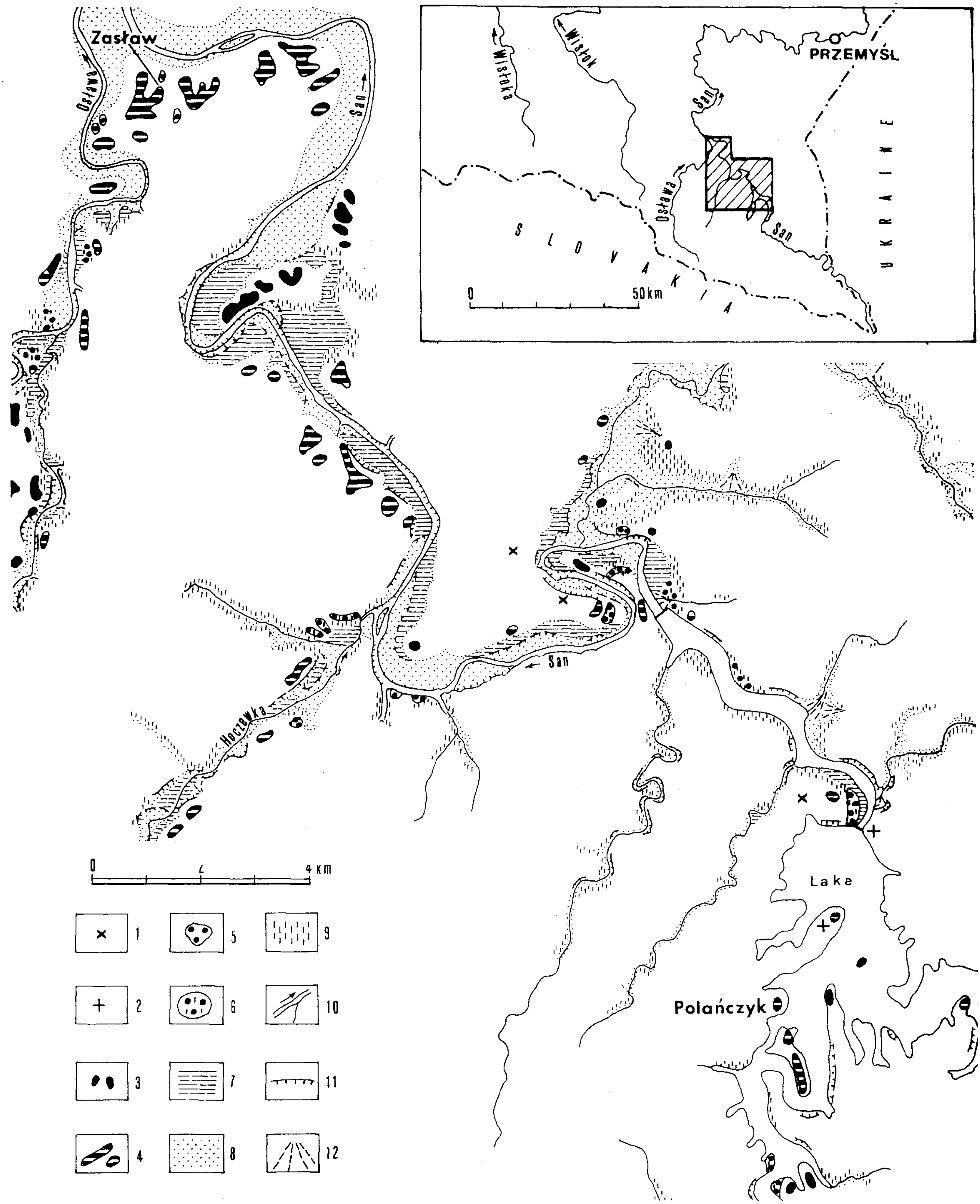

Fig. 1. Quaternary terraces in the upper San valley (after Starkel 1965, slightly changed). 1 — localities with gravels at 100–115 m above river channel, 2 — localities with gravels at 70–80 m elevation, 3 — 40–60 m high terrace without thick loamy cover, 4 — 40–60 m high terrace with loamy cover, 5 — middle terrace 15–20 m high without loamy cover, 6 — 15–25 m middle terrace with loamy cover, 7 — 6–10 m high terrace (Vistulian), 8 — 3–4 m high floodplain (Holocene), 9 — solifluctional-deluvial glacis, 10 — rivers, 11 — edges and undercuts, 12 — alluvial fan

Ryc. 1. Czwartorzędowe terasy w dolinie górnego Sanu (wg. Starkel 1965, nieco zmienione). 1 — stanowiska ze żwirami na wys. 100–115 m n.p. rzeki, 2 — stanowiska ze żwirami na poziomie 70–80 m,·3 — terasa 40–60 m bez grubej pokrywy gliniastej, 4 — terasa 40–60 m z grubą pokrywą gliniastą, 5 — terasa średnia wys. 15–20 m z pokrywą gliniastą, 6 — terasa średnia wys. 15–25 m z grubą pokrywą gliniastą, 7 — terasa wys. 6–10 m (vistulian), 8 — równina zalewowa 3–4 m wys. (holocen), 9 — soliflukcyjno-deluwialna równina podstokowa, 10 — rzeki, 11 — krawędzie i podcięcia, 12 — stożek napływowy

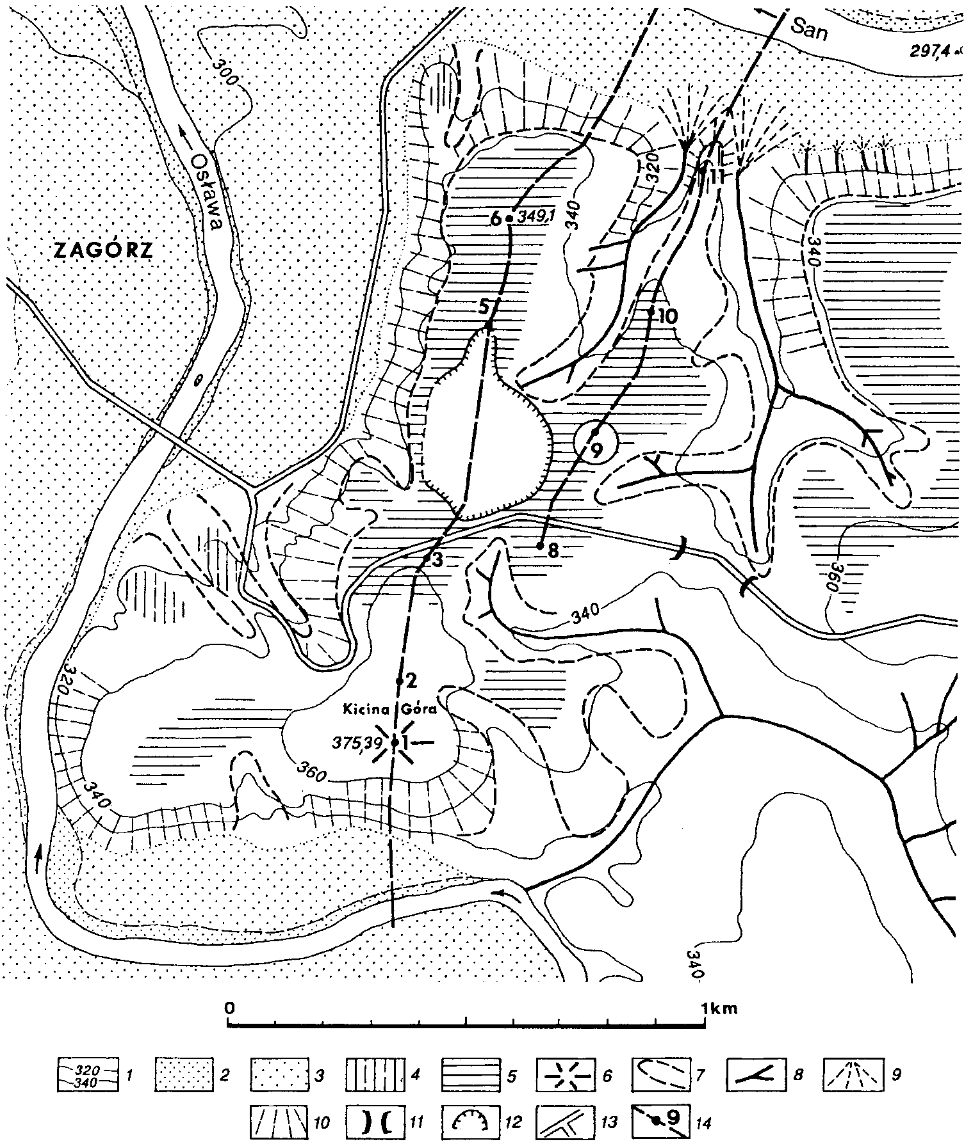

Fig. 2. Geomorphological sketch of the surroundings of Zasław site (by T. Gerlach). 1 — isohypses every 20 m, 2 — floodplain 0.5–1.5 m high, 3 — low terrace 5–7 m high, 4 — middle terrace 19–25 m high, 5 — high terrace 53–56 m high, 6 — wide summit, 7 — tough-like valley, 8 — V-shaped valley, 9 — alluvial fan, 10 — steep valley side over 20°, 11 — pass, 12 — brickyard pit, 13 — road, 14 — cross-section line with numbered borings

Ryc. 2. Szkic geomorfologiczny otoczenia stanowiska Zasław (oprac. T. Gerlach). 1 — poziomice co 20 m, 2 — równina zalewowa o wysokości 0,5–1,5 m, 3 — terasa niska o wysokości 5–7 m, 4 — terasa średnia o wysokości 19–25 m, 5 — terasa wysoka o wysokości 53–56 m, 6 — wierzchołek kopulasty, 7 — dolina nieckowata, 8 — dolina V-kształtna, 9 — stożek napływowy, 10 — zbocze doliny o nachyleniu > 20°, 11 — przełęcz, 12 — wyrobisko cegielni, 13 — droga, 14 — linie przekrojów z numerami wierceń

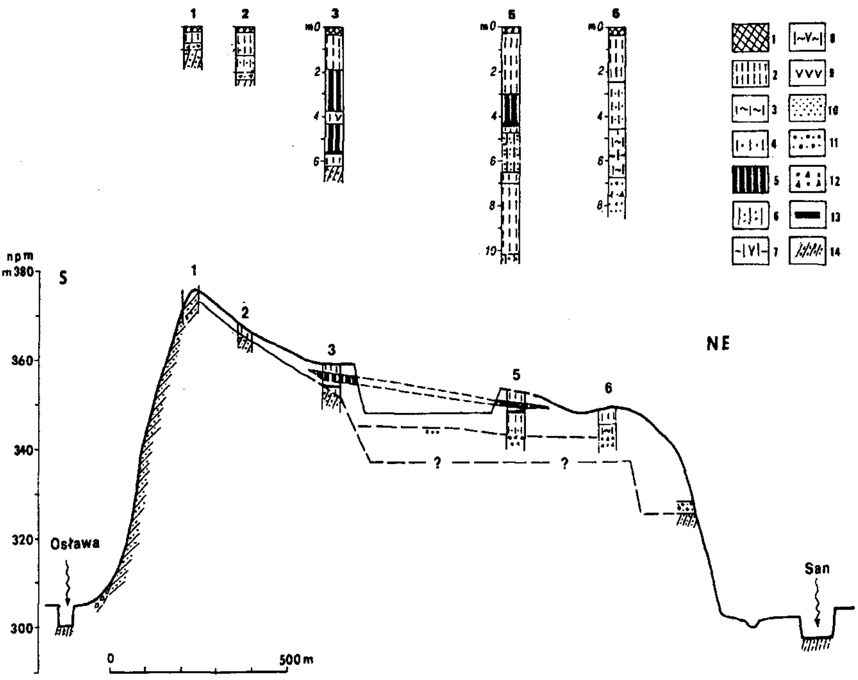

Fig. 3. Geological cross-section I: Osława valley–Kicina Góra–brickyard–San valley (marked on Fig. 2 — by T. Gerlach). 1 — recent soil, 2 — silty loam, 3 — silty loam laminated, 4 — silty-sandy loam, 5 — silty gleyed loam, 6 — sandy-silty loam, 7 — clay-silty mud with organic remains, 8 — silty mud laminated with organic remains, 9 — peat, 10 — sand, 11 — gravels with sand, 12 — gravels with debris, 13 — hard-pan layer, 14 — bedrock

Ryc. 3. Przekrój geologiczny I: dolina Osławy–Kicina Góra–wyrobisko cegielni–dolina Sanu (linia przekroju oznaczona na ryc. 2 — oprac. T. Gerlach). 1 — poziom humusowy (gleba), 2 — glina pylasta, 3 — glina pylasta laminowana, 4 — glina pylasto-piaszczysta, 5 — glina pylasta oglejona, 6 — glina piaszczysto-pylasta, 7 — mułek ilasto-pylasty ze szczątkami organicznymi, 8 — mułek pylasty laminowany ze szczątkami organicznymi, 9 — torf, 10 — piasek, 11 — żwiry z piaskiem, 12 — żwiry z kanciakami, 13 — skorupa orsztynowa, 14 — podłoże skalne

be the Older and Younger Dryas deluvial deposits, separated by a thin clayey iron pan or layer of the Alleröd interstadial.

In order to verify the above concepts two geological profiles have been made based on 11 borings with the mechanical borer "Geomeres" and on observation in the brickyard (Fig. 3 and 4). The drilling were made only to the top of gravels or to the rocky socle.

The flattening is incised in the sandstones of the lower Krosno Beds. It is built of a thick series of various loamy deposits resting on loamed gravels. The top face of the gravels in profile I, is found 44–46 m above the San river channel while the bedrock, according to M. Klimaszewski (1948), at c. 35 m. In profile II the top face of the gravels occurs 37–38 m above the San channel. The difference in the position of the gravel top face in these profiles is c. 7 m.

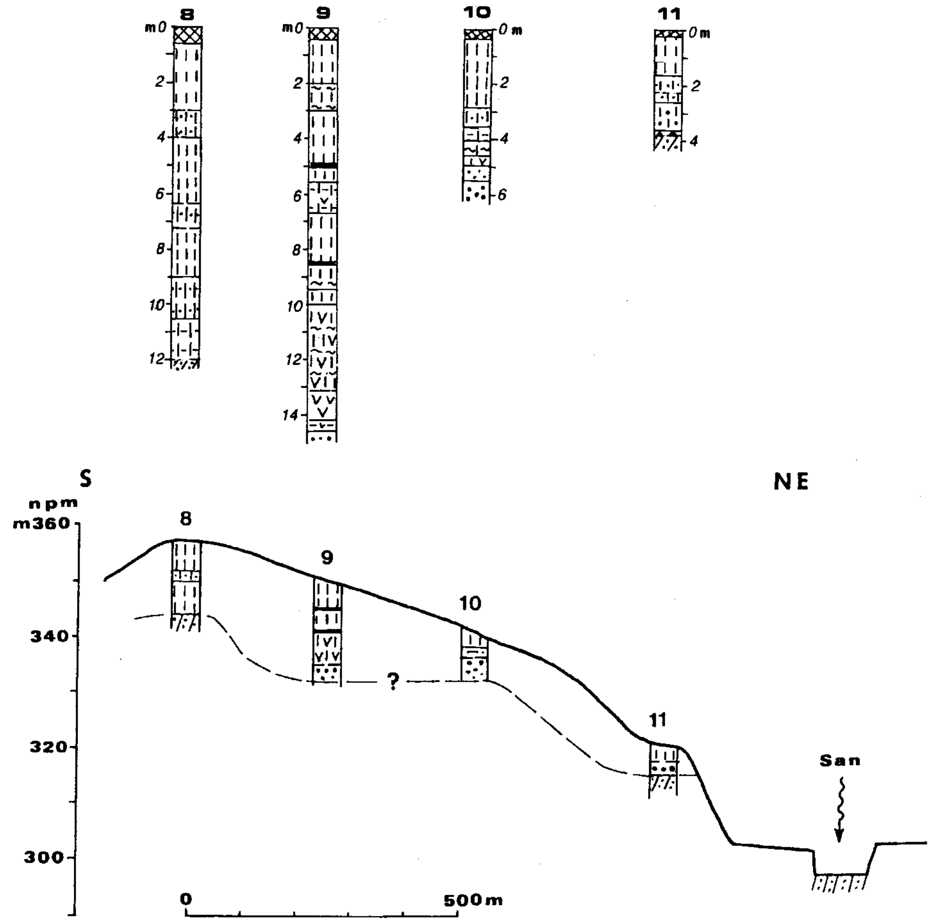

Fig. 4. Geological cross-section II from flattening down to San valley floor (by T. Gerlach). Signs as on Fig. 3

Ryc. 4. Przekrój geologiczny II ze spłaszczenia do dna doliny Sanu (oprac. T. Gerlach). Oznaczenia znaków jak na ryc. 3

In profile I, in loamy deposits three members in different colours can be distinguished. Below c. 30 cm thick humus layer there is the member of the 2–3 m thick yellow and yellow-brown loam. Below the loam, in the upper part of the flattening, there is the member consisting of c. 4 m thick grey-blue gleyed loams underlain with the 5 cm thick iron pan. The member thins out in the middle part of the flattening. Below the grey-blue loams in the middle and lower part occur the 3–7 m thick yellow-brown and yellow-green loams resting on gravels.

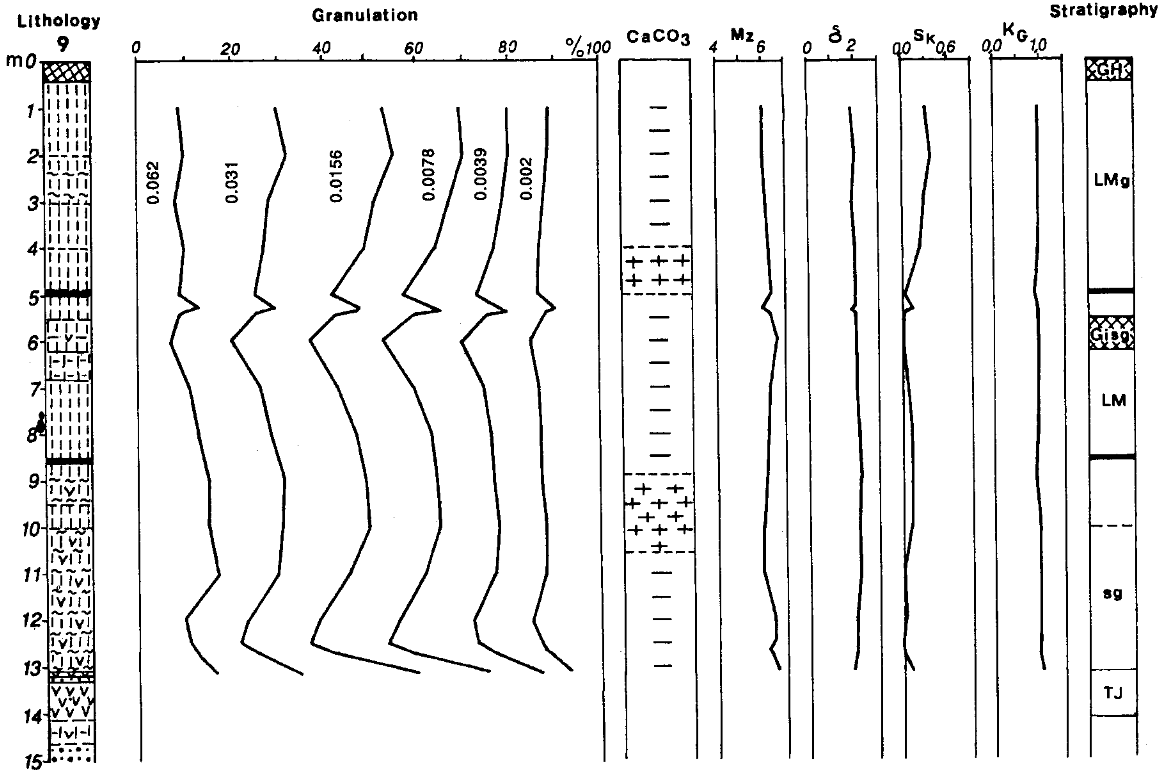

Fig. 5. Profile of boring no 9. Lithology, granulometry, $CaCO_3$ content, granulometric coefficients after Folk-Ward and stratigraphy of silty loams (by T. Gerlach). Litological signs as on Fig. 3. GH — recent (Holocene) soil, LMg — upper younger loess, Gi — interstadial soil, sg — soil sediments, LM — younger loess, TJ — interglacial peat

Ryc. 5. Profil wiercenia nr 9. Litologia, granulometria, węglanowość, wskaźniki granulometryczne wg Folk-Ward i stratygrafia glin pylastych (opr. T. Gerlach). Oznaczenia znaków litologii jak na ryc. 3. GH — gleba holoceńska, LMg — less młodszy górny, Gi — gleba interstadialna, sg — sedymenty glebowe, LM — less młodszy, TJ — torf interglacjalny

In profile II the thickness of the loams in the upper part of the flattening is 12 and 13.6 m, while in the lower part, towards the San river valley, it decreases to 5 and 3 m. In boring 9 in this profile, at the depths of 10–14.6 m, the series of silts and peats was reached (Fig. 5).Taking into account structure, texture, colour, effervescence with HCl three basic deposit members can be distinguished in the profile. On the sandy gravels there are: lower silts, 80 cm thick layer of brown peat and upper, steel-blue silts with organic remnants and do not effervescing with HCl. Their total thickness adds to 4.4 m. These are the deposits filling the abandoned channel that is evidenced by the boring 10, situated 250 m northward, where the top face of the gravels occurs by 1 m higher. The 10 m thick (0.0–10.0 m) series of the yellow-green and grey-blue silty loams with uniform, laminated texture rests on the abandoned channel deposits. At the depth 5.5–6.2 m the series is divided into two members by fossil soil and soil deposits. The upper parts of both members do not contain calcium while the lower ones effervesce with HCl. In the lower member, at the depth of 8.5 m, there is the 10 cm thick layer of hard pan while in the upper member it occurs at the depth of 5 m. Such sequence of deposits points to two periods of deposition of loamy sediments, separated by a period of pedogenic processes. The upper part of the upper member with the iron pan at the base is the result of the Holocene pedogenessis. On the other hand, the top of the lower member with the fossil soil and iron pan at the base should be related either to interglacial or to interstadial pedogenesis.

The abandoned channel deposits are undoubtedly younger than the San Glaciation and seem to be older than the last two cold stages.

SITE POLAŃCZYK

800–1,000 m to the NE of the cemetery in Polańczyk there is the flattening of the high terrace rising 421–425 m a.s.l. and c. 50 m above the old Solinka channel. In the low cliffs, in the axial part of the flattening, a strongly weathered (to 1 m above lake level) rocky socle exposes. A metre layer of coarse gravels and overlying upper loam with distinct flow structures and a wedge structure, filled with loam of a lighter colour, rest on this socle. In the distance of c. 120 m from the shore boring B3 was made on the flattening c. 8 m above lake level (Fig. 6, 7). The following members were bored:

0.00–1.55 — yellow-brown, silty-sandy loam,
1.55–3.15 — olive-grey loam, alternating silty and sandy layers,
3.15–3.73 — silty clay interlaminated with sand,
3.73–3.82 — peaty clay,
3.82–3.87 — organic silty clay,
3.87–4.02 — compacted peat with wood,
4.02–4.95 — organic, silty and sandy clay,
4.95–6.00 — sand with gravel, 2–5 cm in diameter.

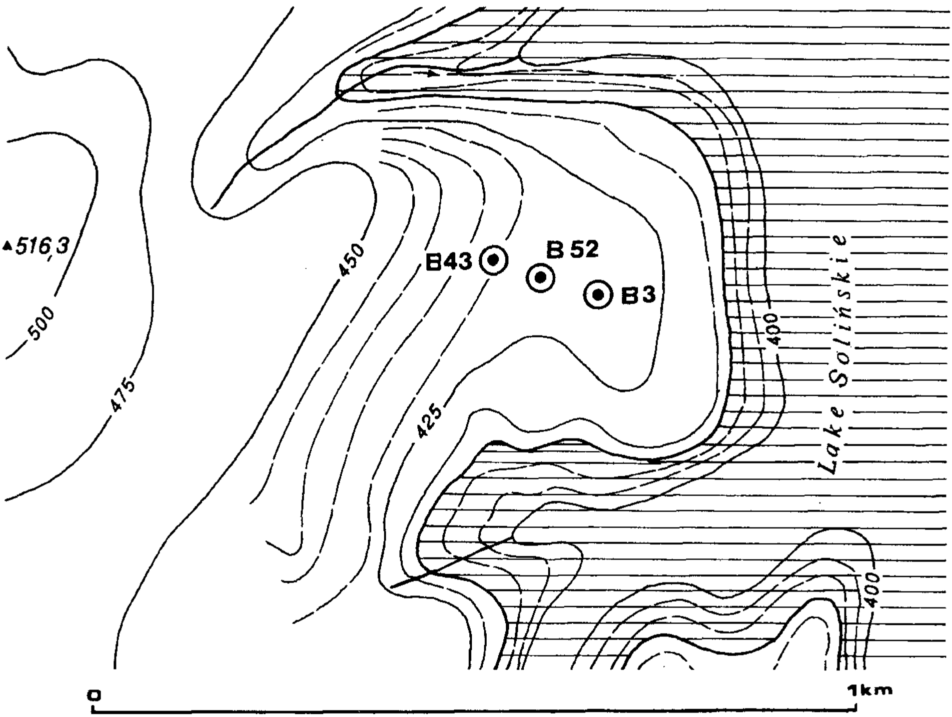

Fig. 6. Location of borings on the 50–60 m high terrace in Polańczyk (interglacial peat was cored at B3 and B52 — cf. Fig. 7 and 9)

Ryc. 6. Położenie wierceń na 50–60 metrowej terasie w Polańczyku (torf interglacjalny nawiercony w B3 i B52 — por. ryc. 7 i 9)

To obtain better samples for pollen analysis additional cores of an undisturbed structure were taken from the depth 3–4 m. The deposits between 4.95 and 3.15 m have character of an abandoned channel fill (deposited in overgrowing reservoir). The overlaying materials are slope loams and their thickness decreases towards the edge of the flattening.

In 1996, in the distance of 85 m from boring B3 another boring B52 (1.5 m above B3) was made. The latter drilled through 4.38 m of silty-sandy loam, and below 2.27 m of silty deposits of the abandoned channel fill, including 1.40 m of peat and peaty mud. One should conclude that the axis of the abandoned channel was closer to the valley slope. Samples for pollen analysis were also taken from drilling B52. In the next drilling B53 at the foot of the slope the rocky socle was drilled below slope deposits at the depth of 3.75 m (Fig. 6).

The analysis of the profile shows that a thin layer of alluvia rests on the rocky socle and that this layer was probably deposited after removal of the main series from the high terrace. The alluvia were deposited before the abandonment of the channel which was filled in a warmer period when the supply from the slopes was limited. In the following cold period the layer was covered with

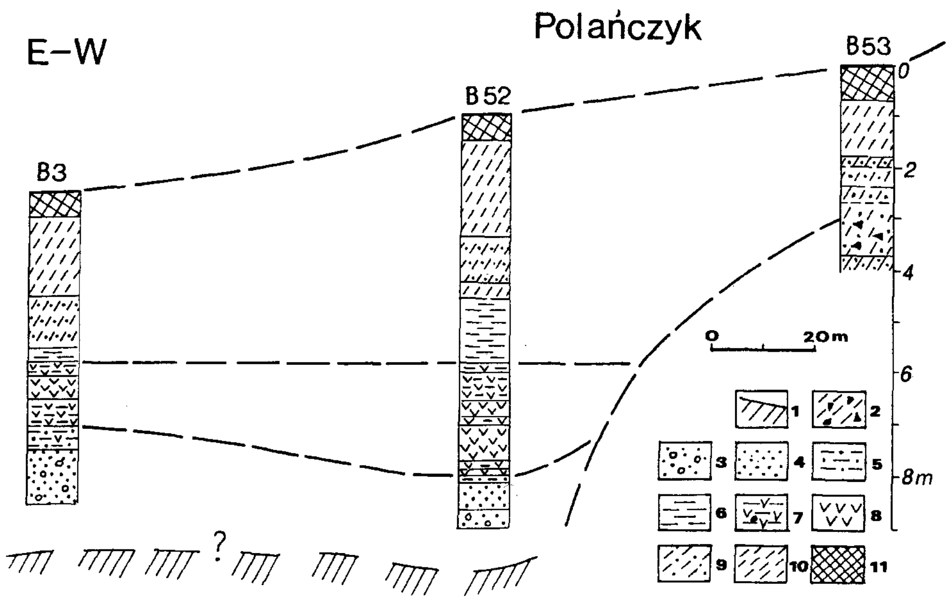

Fig. 7. E-W cross-section of high terrace in Polańczyk (by L. Starkel). 1 — bedrock, 2 — weathered bedrock, 3 — gravel with sand, 4 — sand, 5 — sandy mud, 6 — mud or clay, 7 — peaty mud, 8 — peat, 9 — sandy loam, 10 — silty loam, 11 — humus horizon (soil)

Ryc. 7. Przekrój E-W wysokiej terasy w Polańczyku (oprac. L. Starkel). 1 — skała, 2 — zwietrzała skała, 3 — żwir z piaskiem, 4 — piasek, 5 — mułek piaszczysty, 6 — mułek lub ił, 7 — mułek torfiasty, 8 — torf, 9 — glina piaszczysta, 10 — glina pylasta, 11 — poziom humusowy (gleba)

the slope deposits which were descending downward the high terrace scarp. The scarp was subjected to a slow retreat. The narrow terrace bench did not support accumulation of thicker slope covers (cf. Dziewański, Starkel 1967) in the last cold stage. The abandoned channel deposits seem to represent the period after the San Glaciation, i.e. the period undoubtedly older than the last interglacial (Fig. 8).

RESULTS OF POLLEN ANALYSIS OF ZASŁAW AND POLAŃCZYK

MATERIAL AND METHODS

Sediment samples for pollen analyses from Zasław were taken from borehole number 9 (Fig. 4, 5). 17 samples were obtained in sections of 6.5 cm each between depths of 13.10 and 14.10 m (samples 3 and 4 were taken in sections of 13 cm).

Samples from Polańczyk were taken from two boreholes: Polańczyk B3 and Polańczyk B52 (Fig. 6, 7). 22 samples in sections of 4 cm each were

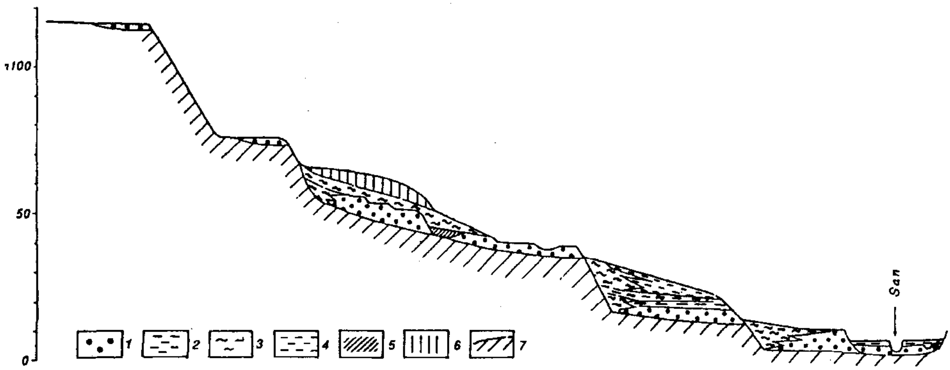

Fig. 8. Scheme of terrace sequence in upper San valley showing relation of slope and fluvial sediments (after Starkel 1965, later changed). Most extensive high terrace, very complicated in their structure. 1 — channel coarse facies, 2 — overbank facies, 3 — solifluction deposits, 4 — deluvial deposits, 5 — paleochannel fill with interglacial flora, 6 — loess deposits, 7 — bedrock

Ryc. 8. Schemat systemu teras w dolinie górnego Sanu (wg Starkel 1965, później zmienione). Rozległa terasa wysoka, bardzo złożona w swej strukturze. 1 — gruboziarnista facja korytowa, 2 — facja pozakorytowa, 3 — osady soliflukcyjne, 4 — osady deluwialne, 5 — wypełnienie paleokoryta z florą interglacjalną, 6 — osady lessowe, 7 — podłoże skalne

obtained from the borehole B3 (Reliable results were obtained from 14 samples number 9 to 22) from 3.16 to 4.21 m from the ground surface. 17 samples from the borehole B52 taken in sections of 4 cm each from 6.05 to 6.92 m and 1 sample from 5.30 m were under study.

The samples were treated with cold, concentrated hydrofluoric acid and subjected to the Erdtman's acetolysis before microscopic analysis. Between 200 and over 500 pollen grains of trees, shrubs and herbs were identified and counted. The results of the microscopic analyses are given on the pollen diagrams obtained with the use of the POLPAL computer programme (Fig. 9). The calculations were based on the basic pollen sum (100%) including trees, shrubs and terrestial herbs. The percentage of pollen from aquatic and swamp plants and spores was calculated by adding an amount of sporomorphes of particular taxa to the basic pollen sum.

RESULTS

All three pollen diagrams are similar to each other in substantial details as far as the flora composition and the trends in plant succession are concerned, although they represent deposits of different periods of sedimentation. The oldest horizon was reached in the profile of Polańczyk B52, slightly younger is the base in Polańczyk B3, and again later starts the profile of Zasław. However, the diagrams are differentiated by the presence of local vegetation. This refers first of all to the occurrence of *Osmunda* spores in Polańczyk (missing in

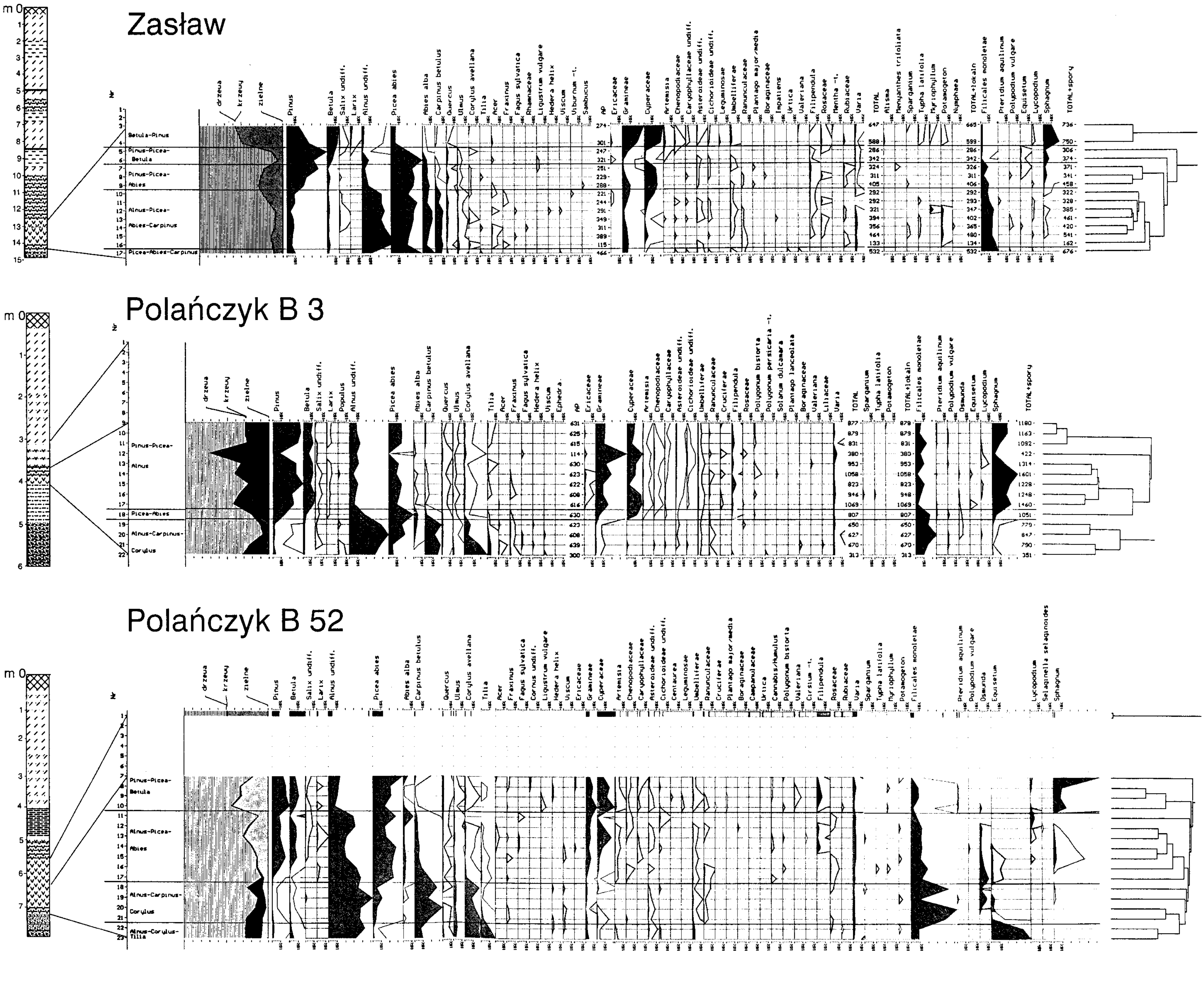

Fig. 9. Palinological diagrams of the peat materials from Zasław and Polańczyk. 1 — humus horizon, 2 — silty loam, 3 — silty loam, laminated, 4 — sandy loam, 5 — clay, 6 — silty loam with organic remains, 7 — clay-sandy mud, 8 — peaty mud, 9 — peat, 10 — sand, 11 — gravel with sand, 12 — hard pan layer (by K. Szczepanek).

Zasław) and of *Abies* pollen, which is much more abundant in Zasław than in Polańczyk.

The bottom samples of Polańczyk B52 diagram consist of a significant amount of *Alnus*, *Corylus* and *Tilia* pollen. In the bottom section of the Polańczyk B3 profile, the continuous high curves of *Corylus* and *Tilia* decrease while the curve of *Picea* rises and of *Carpinus* reaches its maximum. The bottom samples of the Zasław diagram reflect the younger sequence of the flora succession with a decreasing amount of *Carpinus*, and dominant values of *Alnus*, *Picea* and *Abies*.

The local pollen assemblage zones (LPAZ) distinguished in three pollen diagrams are not identical. Taking into consideration the pollen profiles of the upper San river basin, it is possible to distinguish four regional pollen assemblage zones (RPAZ) from the bottom upwards (Mamakowa 1989).

1. RPAZ of *Corylus–Quercus–Tilia* corresponds to Polańczyk B52 LPAZ of *Alnus–Corylus–Tilia*. This zone is present only in the Polańczyk B52 diagram, and is characterized by abundant occurrence of *Alnus* (max. 43%), *Corylus* (max. 19.2%), *Tilia* (max. 17.2%), *Quercus* (max. 1.4%) and *Ulmus* (max. 4.7%). Of the herbaceous plants; *Equisetum* (max. 46.7%) appears, as well as an increasing curve of *Filicales monol.* (max. 9.2%).

2. RPAZ of *Carpinus–Corylus–Alnus* corresponds to Polańczyk B52 LPAZ of *Alnus–Corylus–Carpinus*; Polańczyk B3 LPAZ of *Alnus–Carpinus–Corylus*. The curves of *Tilia* and *Corylus* decrease rapidly near the upper boundary of the pollen zone. *Carpinus* (max. 33.7–27.2%; 19–20.2%) and *Alnus* (max. 52.6% and 46.9%) are dominant with double-peaked curves. The curves of *Picea* (4.3–11.4% max. and 4.9–19.9% max.) increase. The maximum values of *Filicales monol.* (max. 53.1% and 24.7%) and spores of *Osmunda regalis/claytoniana* also appear here.

3. RPAZ of *Picea–Abies* corresponds to Polańczyk B52 LPAZ of *Alnus–Picea–Abies*; Polańczyk B3 LPAZ of *Picea–Abies*; Zasław LPAZ of *Picea–Abies–Carpinus* and of *Alnus–Picea–Abies–Carpinus*. The transitional zone is formed differently in the three above mentioned diagrams. The local pollen assemblage zone (LPAZ) of *Picea–Abies* of the Polańczyk B3 profile was assumed to be a representative zone. It is characterized by high values of *Picea* (max. 28.2–29.7–37.2%) and *Abies* (12.4–5.3–15%). The high curve of *Alnus* (max. 38.2–18.1–34–7%) shows a falling trend. The same declining curve, occurs in *Carpinus* and *Filicales monol.* excluding *Osmunda*, but more distinctly. Regarding the curve of *Osmunda*, it reaches maximum values (9.9%) in this Polańczyk B52 diagram zone. The curves of *Pinus*, *Betula*, *Poaceae*, *Cyperaceae* and *Sphagnum* increase. The low curve of *Larix* (max. 0.4–1.4%) appears and the frequency of herbs increases and enriches the vegetation.

4. RPAZ of *Pinus* corresponds to Polańczyk B52 LPAZ of *Pinus–Picea–Betula*; Polańczyk B3 LPAZ of *Pinus–Picea–Alnus*; Zasław LPAZ of *Pinus–Picea–Abies*, of *Pinus–Picea–Betula* and *Betula–Pinus*. The zone is characterized by increasing

values of pollen of *Pinus* (max. 38–35.7–20.8%), *Betula* (max. 13.9–13.8–18.5%), *Poaceae* (max. 26–87.6–13.4%), *Cyperaceae* (max. 23.6–38.2–21.7%) and spores of *Sphagnum* (max. 18.9–31.2–53.9%). *Alnus* (max. 8.2–13–14%) and *Picea* (max. 38–16.2–36.1%) show a declining trend in their frequency but at the same time herbs, other than the above mentioned, especially *Artemisia* and *Chenopodiaceae* are more frequent although values of both taxa are not high (*Artemisia* max. 1.3–1.8–3.8%); *Chenopodiaceae* (max. 1.5–1.6–0.8%). The zone is marked by the continuous occurrence of *Larix* pollen although its occurrence is not frequent.

DISCUSSION

The development of the plant cover of the upper San river basin and its close neighbourhood, which is reflected in the three analysed diagrams of pollen is transitional in character. The forest communities with their share of mixed forest trees (*Tilia*, *Ulmus*, *Quercus*, *Corylus*, *Alnus*) tend to change to pine-spruce-birch forests marked with larch, through the dominant mixed alder-hornbeam forests with declining taxa (*Tilia*, *Corylus*) of higher thermal demands, and boreal forests of alder-spruce-fir.

The increase of the frequency and diversity of herbs points out the progressive loosening of dense forest communities. The distinct decline of the amount of *Filicales* spores and the rise of the curve of *Sphagnum* spores are a sign of acidic and oligotropic habitats.

The Zasław and Polańczyk pollen diagrams reflect only the late interglacial part of pollen succession. With reference to the optimum phases, the diagrams are incomplete and result in giving vague foundations for correlation among diagrams. Based on the flora composition and the regression trend of the succession of the specific taxa and plant communities (in particular forest communities), it is possible to state that pollen diagrams represent the late interglacial succession after the interglacial optimum. That is to say, that the late interglacial succession occured at the end of the third and the beginning of the fourth period according to a four fold division of interglacial succession (Szafer 1953; Janczyk-Kopikowa 1991). These results of pollen analyses do not provide a sufficient basis to establish a stratigraphic position. It is possible to assume that, regarding the Zasław and Polańczyk pollen diagrams, the significant values of *Tilia* and *Corylus* which are below the rising curve of *Carpinus*, and the maximum value of *Carpinus* below maximum of *Abies* in the bottom section of Polańczyk B52 pollen diagram, make it possible to assume that the analysed pollen diagrams originate from the late Eemian interglacial. This statement may also be supported by the occurrence of high values of *Picea* (max. 38–29.7–36.1%) and no traces of *Pterocarya* pollen, which are distinctive features of the Mazovian interglacial pollen diagrams of this phase of plant succession (Krupiński 1995). The pollen diagrams of other known interglacial plant succession differ considerably from the diagrams of Zasław and Polańczyk (Janczyk-Kopikowa 1991).

CONCLUSIONS AND DISCUSSION

The profiles with organic deposits representing the post-optimum time in one interglacial period are located c. 30 km apart. Based on the pollen analysis it is not very clear which part of the interglacial period they represent. However, they are most similar to the diagrams of the Eemian interglacial from the Polish Lowland.

In the Polish Flysch Carpathians there are lacking the sites from the older and younger interglacials that could allow for comparison. Both the profiles lay on 35–40 m high rocky socles, higher than 10–15 m socles of the terrace that is related to the Middle Polish glaciations (the Oder and Warta river glaciations), and on which twofold slope covers rest (Dziewański and Starkel 1967). Thus dissection of the 35–40 m socle had to take place prior to the Middle Polish glaciation at least (Fig. 8). The troughs cut in alluvia can represent one of the interglacials between the San and Oder glaciation (the Masovian). On the other hand, the twofold character of the loamy covers in Zasław does not exclude their Vistulian age. If it is the case, the peat might represent the last interglacial.

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REFERENCES

Cegła J., 1963. *Porównanie utworów pyłowych kotlin karpackich z lessami Polski.* Annales UMCS, Sec. 3, 18, 4, 69–116.

Dziewański J., Starkel L., 1961. *Geneza i wiek terasy wysokiej w dolinie Sanu.* Rocznik P. T. Geol. 31, 2–4, 461–476.

Dziewański J., Starkel L., 1962. *Dolina Sanu między Soliną a Zwierzyniem w czwartorzędzie.* Prace Geogr. 36, 1–86.

Dziewański J., Starkel L., 1967. *Slope covers on the middle terrace at Zabrodzie upon the San.* Studia Geomorph. Carpatho-Balcanica 1, 21–35.

Gerlach T., Krysowska-Iwaszkiewicz M., Szczepanek K., Pazdur M.F., 1993. *Nowe dane o pokrywie karpackiej odmiany lessów w Humniskach koło Brzozowa.* Zeszyty IG i PZ PAN 16, 1–43.

Janczyk-Kopikowa Z., 1991. *Problemy palinostratygrafii glacjalnego plejstocenu Polski z uwzględnieniem wyników analizy pyłkowej osadów interglacjalnych z Besiekierza — Środkowa Polska.* Annales UMCS 56, supl.1, Sec. B, 1–26.
Klimaszewski M., 1936. *Z morfologii doliny Sanu między Leskiem a Przemyślem.* Przegląd Geogr. 16, 107–132.
Klimaszewski M., 1948. *Polskie Karpaty Zachodnie w okresie dyluwialnym.* Prace Wrocławskiego Tow. Nauk., Seria B, 7, 1–235.
Krupiński K.M., 1995. *Stratygrafia pyłkowa i sukcesje roślinności interglacjału mazowieckiego w świetle badań osadów z Podlasia.* Acta Geogr. Lodz. 70, 1–200.
Łanczont M., Butrym J., Pękala K., 1988. *Stratigraphic and palaeogeographic significance of Quaternary deposits from the Optyń Hill near Przemyśl, East Carpathians.* Quaternary Studies in Poland, 79–84.
Mamakowa K., 1989. *Late Middle Polish glaciation, eemian and early Vistulian vegetation at Imbramowice near Wrocław and the pollen stratigraphy of this part of the pleistocene in Poland.* Acta Palaeobotan. 29(1), 11–176.
Starkel L., 1960. *Mapa geomorfologiczna Polski 1:50 000, Arkusz Lesko.* IG PAN.
Starkel L., 1965. *Rozwój rzeźby polskiej części Karpat Wschodnich na przykładzie dorzecza górnego Sanu.* Prace Geogr. 50, 1–160.
Szafer W., 1953. *Stratygrafia plejstocenu w Polsce na podstawie florystycznej.* Rocznik Pol. Tow. Geol. 22, 1, 1–99.
Zuchiewicz W., 1987. *Evolution of the Eastern Beskid Niski Mts. and morphotectonics of the Polish Carpathians.* Zeszyty Naukowe AGH 1156, Geologia, 1–168.

STRESZCZENIE

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STANOWISKA ORGANICZNYCH OSADÓW INTERGLACJALNYCH W DORZECZU GÓRNEGO SANU (POLSKIE KARPATY WSCHODNIE)

W 1995 roku na terasie wysokiej Sanu i Solinki (40–60 m) zostały odkryte stanowiska torfu z florą interglacjalną (ryc. 1). W Zasławiu koło Zagórza T. Gerlach stwierdził 4 metrową serię osadów starorzecznych pod 10-metrową warstwą glin lessowych (ryc. 2–5). W Polańczyku nad zbiornikiem Solińskim L. Starkel rozpoznał pod 3–5 m glin stokowych 2,3 m serię osadów starorzecznych (ryc. 6, 7). Przewarstwienia organiczne były przedmiotem analizy pyłkowej wykonanej przez K. Szczepanka (ryc. 9).

Osady te leżą na aluwiach złożonych na wysokich cokołach skalnych. Cokoły skalne są wyższe od cokołów terasy ze zlodowacenia środkowo-polskiego i należy je wiązać ze zlodowaceniami południowo-polskimi (sanu). Obecność poziomu gleby kopalnej z orsztynem w Zasławiu wskazuje, że osad starorzeczny jest starszy od interglacjału eemskiego, o ile gleba ma rangę interglacjalną.

W świetle analizy pyłkowej badane profile reprezentują część pooptymalną okresu interglacjalnego (obecność *Carpinus*, *Abies* i in.). Diagramy najbardziej zbliżone są do sekwencji interglacjału eemskiego na Niżu Polskim. Ale w Karpatach brak jest niestety porównywalnych stanowisk zarówno eemskiego, jak i starszych interglacjałów. Jeśli rozcięcie cokołu nastąpiło przed zlodowaceniem środkowo-polskim, z którego jest niższa terasa z dwudzielną serią osadów stokowych (np. w Solinie-Zabrodziu — ryc. 8), to rynny kopalne z torfem winny reprezentować interglacjał starszy (mazowiecki?).