ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN — POLONIA
VOL. XLVI, 2, 21-52 SECTIO B 1991

*Department of Physical Geography, Maria Curie-Skłodowska University, Akademicka 19, 20-033 Lublin, Poland; **Department of Geology, Maria Curie-Skłodowska University, Akademicka 19, 20-033 Lublin, Poland; ***State Geological Institute, Rakowiecka 4, 00-975 Warszawa, Poland

Jerzy BUTRYM*, Marian HARASIMIUK**, Zofia JANCZYK-KOPIKOWA***, Henryk MARUSZCZAK*

# Intersaalian Organogenic Deposits and Forest Soils in the Łęczna Environs (SE Poland)

**Intersaaliańskie osady organogeniczne i gleby leśne w okolicy Łęcznej (Polska SE)**

## ABSTRACT

The studied sediments occur among the layers accumulated after the phase of glaciofluvial sedimentation in this area, but before the formation of Vistulian loess-like deposits. The geological data and TL datings indicate that glaciofluvial sediments represent the Odranian glaciation (=Saalian I). Organogenic boggy-lacustrine sediments are characterized by a pollen spectrum with the development sequence typical for the interstadial. A cool variety of moderate climate prevailed in the optimum phase of the vegetation development. Parallelly to the formation of these deposits brown forest soils were developing. The profile of these soils was later overlaid with the turf horizon formed in transitional climate — from boreal to subarctic. A paleogeographic analysis of the organogenic sediments and of this polygenic soil (pedocomplex), as well as TL datings made possible the correlation of the reconstructed events with the successive phases of $^{18}O$ stage 7 of deep-sea sediments. The pollen spectrum of the boggy deposits appeared to be very similar to that in the neighbouring sites examined earlier at Łańcuchów and Podgłębokie (Z. Janczyk-Kopikowa 1969, 1979). The period of peat formation in these two sites was then correlated with Brörup interstadial. The data presented here, as well as TL datings carried out for the sediments at Łańcuchów prompt the need to revise that view. In this connection the authors present an attempt to compare the events which occurred in the discussed area during the period corresponding to stage 7 of $^{18}O$ (Lublinian=Treenian=Odintsovian) and to stage 5 of $^{18}O$ (Eemian).

## INTRODUCTION

During the building of a collector network in a new living quarter of Łęczna in 1984, layers of organogenic deposits were exposed at a depth of about 6.5 m. They appeared in the geologic-morphological position similar to that of organogenic deposits found earlier in the neighbouring localities: Łańcuchów (A. Jahn 1956, E. Rühle 1956) and Cyców-Podgłębokie (Z. Janczyk et al. 1960). The layers of peat in the two localities were examined paleobotanically in detail, and on this basis they were finally qualified as representing the same interstadial period. The pollen sequence was then determined as corresponding best to the early Vistulian Brörup interstadial (Z. Janczyk-Kopikowa 1969, 1979). Such a determination of the stratigraphic position may have resulted from the detailed examination of the geological situation of the site at Podgłębokie (J. E. Mojski and J. Rzechowski 1969).

The classification of organogenic deposits of Łańcuchów and Podgłębokie into Brörup interstadial had a relatively unambiguous influence on the later attempts at summing up the geological results of geologic-cartographic studies carried out in the Wieprz and Świnka interfluve area of the Łęczna environs. According to these summaries, in the larger part of this interfluve thicker covers of river deposits of the last glaciation, i.e. Vistulian are likely to occur (S. Skompski 1975, M. Harasimiuk and A. Henkiel 1980b, c).

Such a stratigraphic interpretation of organogenic deposits of Łańcuchów and Podgłębokie and the river deposits covering them arose doubts from the geomorphological point of view. This was expressed by H. Maruszczak (1964) on the 1:300 000 geomorphological map of the Lublin district, and then in the contents of the "Lublin" folio of the 1:500 000 General Geomorphological Map of Poland (1980). On the latter map only small areas are marked as terrace levels from the last glaciation. The nearest environs of the sites at Łańcuchów and Podgłębokie have been classified into low "plateaus" with a relief determined by the older stratum covered with deposits of Saalian glaciation.

To explain the discrepancies in interpretation in the geologic-morphological situation of the mentioned sites of interstadial sediments, in 1984 detailed studies were undertaken on organogenic deposits exposed during the building of a collector in Łęczna. Samples were taken from several exposures for detail paleobotanical analyses (Z. Janczyk-Kopikowa), to document the sedimentologic interpretation of the distinguished series of layers (M. Harasimiuk) and for litho- and pedo-stratigraphic interpretation

(H. Maruszczak). The results of studies of these exposures are presented against the general geologic-morphological characteristics of the region investigated, illustrated by geomorphological scheme (H. Maruszczak) and a geological cross-section (M. Harasimiuk).

## METHODS

From the introduction it appears that paleobotanical studies were considered to be basic ones. They constituted an unequivocal basis to refer to the results of earlier studies of the sites at Łańcuchów and Podgłębokie. That this is the most valid basis is also determined to a high extent by the fact that paleobotanical analyses of the deposits at Łęczna were made by Dr. Z. Janczyk-Kopikowa from the State Geological Institute in Warsaw, the author of analogous studies carried out for the sites at Łańcuchów and Podgłębokie. The paleobotanical analyses were carried out by standard methods for micro-remnants seperated from samples which the author took herself from a section in the terrain in 1984.

Samples for dating by the thermoluminescence method (TL) were taken from outcrops by Prof. Dr. H. Maruszczak in outcrops 1, 2 and 4A. TL analyses and interpretation of their results to determine the age were carried out by Dr. J. Butrym in the Department of Physical Geography, Maria Curie-Skłodowska University (UMCS) in Lublin. He used the additive method for calculating the geological dose with the consideration of the linear dependence of the TL effect on the additional doses of artificial irradiation (J. Butrym 1985). Measurements of the annual dose were made by thermoluminescence dosimeters LiF:Mg,Ti. The results of dating presented in the paper are given with approximate error specific for the laboratory technique used. It should be stressed that undefined was the error resulting from the adopted assumption that in the analysed grains the stored TL originating from the previous layer of their occurrence had been "zero — pointed" in the moment of their deposition in the layers studied. Such an assumption is most likely only in the case of grains of loess deposits, which underwent a longer eolian trasport. Grains of other sediment environments had a considerably bigger chance to preserve the so-called residual thermoluminescence hidden in the deepest "traps" of the crystal lattice. Therefore, a possible overstating TL age of deposit samples, the mineral grains of which underwent a too short transport should be taken into consideration.*

* The results of TL dating from the Lublin laboratory are fully convergent with those

Sedimentological analyses were carried out in the laboratory of the Institute of Earth Sciences, UMCS in Lublin. Sixty basic samples for these analyses were taken by Doc. Dr. M. Harasimiuk from all distinguished series of deposits of the examined sections in the digging of the collector. For sandy deposits the analyses were carried out by the sieve method, and for deposits of fine fractions by the pipette method.

By means of the computer programme "Fractions" basic granulation indices were calculated according to Folk and Ward. For sedimentological characteristics of middle- and upper-Pleistocene deposits of the Łęczna environs, also archival results of analyses and calculations of granulation indices were utilized, which were performed by the same methods for 50 samples from reasearch core drills located in the area dealt with in this paper (M. Harasimiuk and A. Henkiel 1980a).

Pedostratigraphic analysis was carried out by H. Maruszczak, above all on the basis of the study of exposures extending at a distance of several dozens of metres with outcrops 1–2 and 3–4. Several samples for detailed paleopedological analyses were taken only from one fragment of these exposures, in outcrops 4A and 4B, jointly with Prof. Dr. Konecka-Betley of the Soil Science Department, University of Agriculture in Warsaw. The results of these analyses are presented in a separate paper (K. Konecka-Betley and H. Maruszczak 1989), which also refer to several other sites of inter-Saalian (Saalian I/Saalian II) soils.

## GEOLOGICAL-MORPHOLOGICAL CHARACTERISTICS OF THE AREA

The Łęczna environs (23 km ENE of Lublin) belong to the border zone of the Lublin Plateau and the Lowland of Western Polesie. It is built largely of carbonate rocks of the upper Maestrichtian, represented by more resistant opokas and marly opokas, as well as by little resistant marls and chalk rocks. The surface of these rocks was remodelled by denudation on the turn

obtained in the laboratory of the Institute of Geological Sciences, Academy of Sciences of the Ukraine SSR in Kiev. Among other things, this was shown by experiments of parallel dating in both laboratories of a series of 20 loess samples taken in co-operation in the region of Luck (V. N. Shelkoplyas et al. 1985). Such TL analyses made in Heidelberg in Max-Plank-Institut für Kernphisik gave for loess deposits results fully convergent with those obtained in the Lublin laboratory. Moreover, in the Heidelberg laboratory it was found that TL datings are reliable not only in the interval up to 100 ka, as it is accepted in some laboratories. For loess deposits in West Germany results reliable from the geological point of view were obtained in the interval up to 300 ka (L. Zoeller and G. A. Wagner 1987).

of Pliocene and Pleistocene. The planation surface formed at that time belongs to the lowest situated system among 3–4 major degradation surfaces distinguished on the Lublin Plateau (A. Jahn 1956, H. Maruszczak 1972; M. Harasimiuk 1980). This planation surface is at present 170–180 m a.s.l. in the Łęczna environs (Fig. 1). Its relief is differentiated in relation to the properties of the bedrocks — the outcrops of soft upper-Cretaceous limestones (chalk) are characterized by the occurrence of karst dolines (Fig. 2). Above the surface characterized, denudation remnants of higher planation (190–200 m a.s.l.) rise. These remnants occur in wider fragments westwards and south-westwards from the area presented in Fig. 1. Within the higher planation level patches of Paleocene gaizes with interbeddings of opokas and limestones, covering rocks of the upper Maestrichtian, have been preserved.

In the oldest Pleistocene (Protopleistocene), a wide valley of the proto-Wieprz river cut into an extensive area of low planation surface to a depth of about 70 m. At that time this river was flowing in the meridional direction, differently than at present, at a distance of about 6 km eastwards from the present valley at Łęczna. In the following stage of relief development, in middle Pleistocene, this valley was partly buried. On its western side an enigmatic system of very narrow and deep to 100 m gullies of "transitional" drainage developed at that time. These forms cut transversely the previously buried valleys of the left-side tributaries of the old Wieprz river (Fig. 2B). They were totally buried relatively rapidly, largely during the Mazovian interglacial (M. Harasimiuk and A. Henkiel 1980a). The evident proof of their existence are the present inversive, sloping ramparts rising up to several metres above the surrounding surfaces (Fig. 2A). This peculiar inversion is interpreted by chemical denudation progressing more intensively on the outcrops of carbonate rocks of upper Maestrichtian than in Quaternary deposits infilling the valleys (M. Harasimiuk and A. Henkiel 1977). It may be stressed that we come across a similar, though less spectacular inversion in the zone of the buried wide valley of the old Wieprz river northwards of Łańcuchów — between Ciechanki and Turowola. The present surface, distinguished on the geomorphological map as "higher terrace plains", rises here higher than within the westwards lying low planation of karstificating rocks of the upper Maestrichtian.

The old-Pleistocene Wieprz river valley and middle-Pleistocene gullies were finally buried in the Odranian (=Saalian I). During this glaciation the area discussed was in the extent of the inland ice. During the later interstadial (interglacial?) warming up (Lublinian = Treenian) as well as the following Wartanian (=Saalian II) glaciation and the Eemian interglacial, a


Fig. 1. A hypsometric map of the Łęczna environs. Contour lines drawn every 5 m

new system of the Wieprz river valley was formed. Southwards of Łańcuchów (5 km SE of Łęczna) the river cleared its old valley. Further down it flowed westwards. At first, i.e. between Łańcuchów and Zakrzów (3 km S od Łęczna), it cleared the estuary of one of its bigger old-Pleistocene tributaries. Below Zakrzów it cut epigenetically to a depth of 30–40 m into the surface of the low planation of rocks of upper-Maestrichtian. In this way a narrow and relatively deep gorge was formed between Zakrzów, Łęczna (Fig. 2A) and Kijany (8 km WNW of Łęczna).

The erosional bottom of the Wieprz river gorge, finally formed in the Eemian, is 10–12 m below the present one (H. Maruszczak 1974). As a result of accumulation during the Vistulian glaciation, the river built it up to about 10 m above the present bottom. This is testified by small fragments of the terrace preserved in the gorge. In the upper Plenivistulian the river modelled in its deposits a lower terrace preserved in still smaller fragments rising 2–3 m above the present bottom. On the turn of the Vistulian and Holocene the river cut in so much that its bottom was several metres below the present. After the middle Holocene period of relative stabilization the river started to built up its bottom again to its present level in the subboreal phase and particularly in the subatlantic.

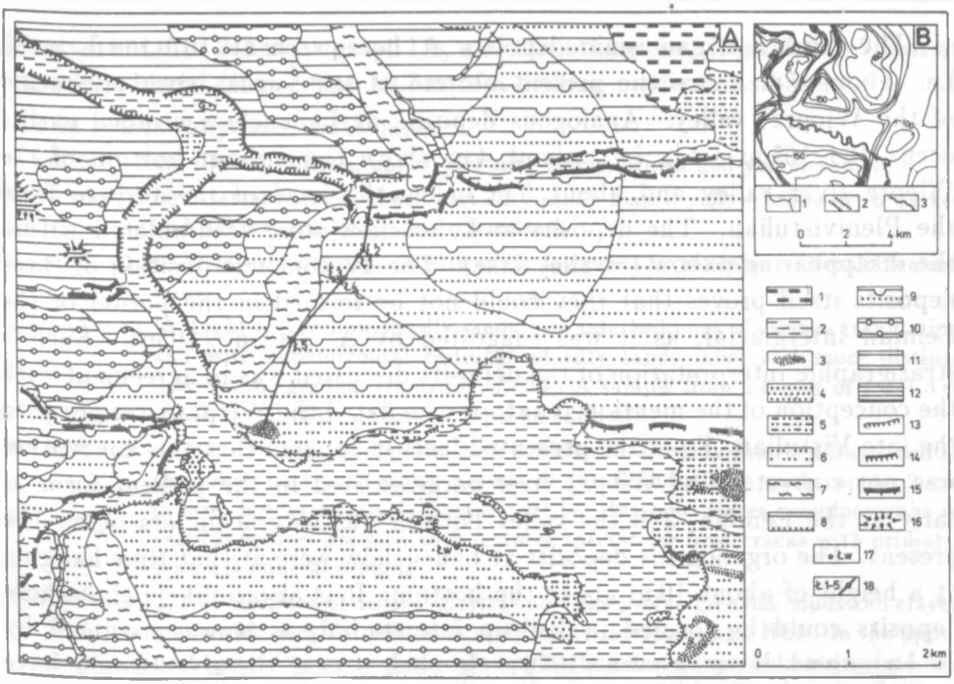


Fig. 2. Geomorphological sketch of the Łęczna environs

A. Recent relief and localization of the studied sites (worked out by H. Maruszczak 1988): 1 — bottoms of wider depressions outside river valleys, covered with organogenic Holocene sediments; 2 — recent alluvial plains built of Holocene alluvial soils and peats; 3 — dunes and eolian sands, late glacial and early Holocene; 4 — lower terraces cut out in alluvial deposits in the upper Plenivistulian; 5 — middle terraces and lacustrine-flood waters plains built of Plenivistulian sands and sandy silts deposits; 6 — Saalian terraces with thin covers of Vistulian sands and silts; 7 — inversive low ridges mainly built of sands and silts deposited in deep, narrow valleys cut in upper-Cretaceous rocks in the middle Pleistocene; 8 — higher terraces built of various Pleistocene deposits of a thickness over 20–30 m; 9 — accumulative-denudative plains with thinner cover of Pleistocene deposits, reproducing karst dolines modelled in upper-Cretaceous rocks; 10 — lower, undulated planation surface developed on karstificating marls and limestones with a discontinuous cover of various Pleistocene sediments well reproducing karst dolines; 11 — lower planation surface cutting of mainly non-karstificating upper-Cretaceous opokas; 12 — higher planation surface cutting of non-karstificating upper-Creataceous and Paleocene rocks; 13 — more distinct edges of Holocene river erosion over 3–5 m in height; 14 — very distinct erosional edges over 5–10 m in height cut out in upper-Cretaceous rocks in gap section of Wieprz river valley; 15 — distinct edges of Wieprz river valley over 3–5 m in height cut out in Pleistocene deposits; 16 — scarps of remnants of higher planation surface formed by denudation from the upper Pliocene; 17 — site of interstadial organogenic sediments of Łańcuchów; 18 — sites of presented inter-Saalian organogenic sediments ($L_{1-5}$ storm water collector) and the line of the geological section presented in figure 3A. B. Relief of the bedrock of Quaternary deposits (worked out by M. Harasimiuk 1988): 1 — contour lines; 2 — steep edges of deep valleys cut out in Cretaceous rocks in the middle Pleistocene; 3 — recent Wieprz channel

The studied organogenic deposits at Łęczna occur 167–168 m a.s.l., i.e. about 7 m above the present bottom of the Świnka river (tributary of the Wieprz) valley. Analogous deposits at Łańcuchów studied earlier occur 164–165 m a.s.l., i.e. about 4 m above the present bottom of the Wieprz river valley and about 5 m below the level of the terrace from the Plenivistulian. The deposits at Łańcuchów were accumulated within the disappearing oxbow (=valley lake). The hypsometric position of these deposits itself proves that they could not be formed in the period of the Eemian interglacial, as it was suggested by A. Jahn (1956). Such a stratigraphic interpretation of the deposits discussed was in agreement with the conception of the mentioned author who dated the Wieprz river gorge to the late Vistulian. From the presented facts it appears that this conception was not correct. The Wieprz river gorge existed in the present form as early as the Eemian, and the valley bottom was several meters below the present. The organogenic deposits at Łańcuchów were at that time hanging at a height of about 10 m above the bottom. It is also unlikely that these deposits could be formed in Brörup interstadial, as it was assumed by Z. Janczyk-Kopikowa (1979). In such a case the river would have to elevate its bottom by at least 8–10 m during the oldest stadial of the Vistulian glaciation, preceding Brörup interstadial.

Such introductory remarks about the stratigraphic position of the organogenic deposits studied by us seem to result from an analysis of the geologic-morphological relationships of this area.

## DESCRIPTION OF THE SELECTED EXPOSURES

The studied organogenic deposits were exposed in 1984 in deep ditches of the collector cutting transversely the Wieprz and Świnka rivers interfluve, in the new living quarter of Łęczna. For exact determination of the character of the deposits and their stratigraphic position several exposures in excessible sections of the collector ditch were examined. The first of such sections was located in the north part of the interfluve at a distance of 700 m southwards from the Świnka river (Fig. 2 and 3).

Exposure 1 and 1A

Point 1 is situated at 176 m a.s.l., on the slope of a dry trough-like valley of dellen type. For a more exact determination of the character of the upper layers an additional exposure 1A was taken into consideration, which was located at 176 m a.s.l. outside the trough-like valley, at a distance of 33 m south-westward from point 1. The enclosed description concerns the upper layers from 0 to 2.3 m at point 1A, and the others, i.e. from 2.3 to 7.6 m at exposure 1, and from 7.6 to 10.7 m of a drilling made at its base.

a) 0.00 — 0.15 Silty-sandy arable layer.

$b_1$) 0.15 — 0.40 Illuvial horizon, upper part silty-loamy, brown and yellow-brown.

$b_2$) 0.40 — 1.00 Illuvial horizon, lower part silty-sandy-loamy, yellow-brown with darker and lighter streaks; gradual transition.

$c_1$) 1.00 —1.15 Yellowish silty deposit with spots; lower border readable — decalcification limit.

$c_2$) 1.15 — 2.30 Light grey-yellowish silty sands with interbeddings of various granulation and with subhorizontal beddings of silty sands more and more distinct downwards; gradual transition; HCl+. A sample from a depth of 1.2–1.3 m dated by the TL method to 25±4 ka (Lub-876).

$c_3$) 2.30 —2.80/2.90 Silty-sandy deposits with subhorizontal sandy interbeddings, and in the lower part with single gravels of the Scandinavian rocks up to 2 cm in size; border relatively distinct; HCl+. In some places pseudomorphs of vertical fissures are seen with features specific for frost cracks with primary, seasonal mineral infilling.

d) 2.90 — 3.15/3.25 Horizon of distinct gleyization — grey-blue-greenish muds and clayey muds with irregular yellowish-rusty sandy interbeddings; HCl-. In the upper part signs of occurrence of secondary carbonates, downward passing into fine concretions. In numerous places there occur solifluctional or involutional disturbances of stratification.

$e_1$) 3.20 — 4.30 Silty and sandy-muddy deposits, ashen-grey and light grey-yellowish stratified subhorizontally; HCl-. In the upper part disturbances of stratification of load cast type.

$e_2$) 4.30 — 5.00 Muddy-sandy grey-bluish deposit with yellow-rusty spots and relatively numerous iron-manganese microconcretions; HCl-. In the upper part distinct ashen-yellowish sandy interbeddings, accentuated by rusty precipitations, disappearing downwards.

$e_3$) 5.00 — 5.20 Sandy-muddy grey-bluish deposit with distinct light grey-dunnish sandy interbeddings and iron-manganese precipitation stains; HCl-.

$e_4$) 5.20 — 5.50 Muds and clayey muds, light grey, with iron-manganese precipitation stains; distinct limit; HCl- (in places small agglomerations of secondary carbonates). In the lower part lenticular inserts of laminated humus deposit originating from an underlying layer. Layers $e_3$–$e_4$ cut by indistinct fissure structures (drying fissures?), part of which reach layer f.

f) 5.50 — 5.80/5.90 Humus horizon of hydrogenic soil, silty and silty-loamy, grey and dark grey-dunnish; HCl- (upper part — small agglomerations of secondary carbonates). Gradual transition or signs of indentation with the underlying horizon in the form of irregular vertical leaks or subhorizontal streaks going down to a depth of 6.25 m.

$g_1$) 5.90 — 6.20/6.30 Horizon with marks of leaching, blue-grey, spotty and granulous with numerous and distinct pseudomorphs of foliaceous structure of fibrous ground ice; gradual transition; HCl-.

$g_2$) 6.20 — 7.00 Horizon of zonal gleying, silty and silty-sandy, blue-grey-greenish, with small rhizocoles of $Fe_2O_3$ oxides; limit readable; HCl-.

h) 7.00 — 7.50 Sandy deposit, grey-yellowish, stratified subhorizontally with grey-greenish, sandy-muddy interbeddings. A considerable content of coarse sand grains, and below single gravels of the Scandinavian rocks up to several centimeters in size; limit distinct.

$i_1$) 7.50 — 8.30 Grey-bluish clayey mud, downwards with a more distinct shade of grey colour.

$i_2$) 8.30 — 8.90 Grey clayey mud, downwards with dunnish shade, and from 8.60 with dun stains.

$i_3$) 8.90 — 9.10 Clayey mud and clay, grey and dark-grey with rusty-dunnish stains and streaks.

$j_1$) 9.10 — 9.25 Clay with peaty mud, dark-grey with grey-dunnish and brown-rusty streaks.

$j_2$) 9.25 — 9.35 Sandy mud with sandy interbeddings, grey-dunnish.

$j_3$) 9.35 — 9.40 Dark-brown-grey peaty deposit.

$j_4$) 9.40 — 9.45 Mud and sandy mud, tobacco brown; HCl-.

$k_1$) 9.45 — 9.85 Clayey mud, grey-beige with brown-rusty stains at the top; HCl-.

$k_2$) 9.85 — 10.00 Grey clayey mud; HCl-.

$k_3$) 10.00 — 10.70 Steel-grey clayey mud; HCl-.

### Exposure 2

A more distinct and thicker layer of peat was found among lacustrine muds (layers i – k) in exposure 2 situated 20 m north-north-eastwards from 1, on the axis of a trough-like valley 175 m a.s.l. This exposure was found more suitable for taking samples for analysis of pollen. From the lithological point of view it differs a little from exposure 1. Therefore, we give its description; from 0 to 7.6 m the results of studies of this exposure, and from 7.6 to 10.3 m of the drilling at its foot.

$a_1$) 0.00 — 0.30 Sandy-silty humus horizon; gradual transition.

$a_2$) 0.30 — 0.70 Horizon with signs of leaching (weak podsolization) and transitional sandy-silty horizon, light-grey, spotted.

b) 0.70 — 2.15 Illuvial horizon, silty-sandy, brown and light-grey-brown, in its middle and lower part — stains and blue-grey streaks with a dunnish-rusty contour (gleyization signs); gradual transition.

c) 2.15 — 2.65 Sandy-muddy and sandy-loamy deposit, bluish-brownish and grey-yellowish, stratified subhorizontally; HCl-.

d) 2.65 — 2.80/3.00 Horizon with distinct gleyization with features as at 1 d; HCl- (without secondary carbonates). A sample from a depth of 2.75 — 2.85 m dated by the TL method to 83±12 ka (Lub-877).

$e_1$) 2.90 — 3.25 Sandy-loamy deposit with a few subhorizontal sandy interbeddings; gradual transition; HCl-.

$e_2$) 3.25 — 3.60 Sandy and sandy-muddy deposit — downwards with more and more distinct thin lamination, grey-dunnish — alternately darker and lighter; the lower limit relatively distinct but irregular — possibly erosional; HCl-.

$e_3$) 3.60 — 3.70/3.75 Sandy deposit, light grey-yellowish, stratified subhorizontally, with spotty bluish-grey mud lenses; distinct limit; HCl-.

f) 3.70 — 4.00/4.10 Humus horizon of hydrogenic soil as at 1 f; HCl- (without secondary carbonates). A sample from a depth of 3.85 — 3.95 m dated by the TL method to 197±29 ka (Lub—878).

$g_1$) 4.10 — 4.20/4.30 Horizon with signs of weak leaching as at 1 $g_1$.

$g_2$) 4.30 — 4.65/4.80 Horizon with zonal gleyization as at 1 $g_2$.

h) 4.65/4.80 — 5.00/5.25 Vari-grained sands stratified subhorizontally, downwards passing to a sandy-muddy deposit, bluish-grey, bluish-dunnish and bluish-greenish; distinct limit; HCl-. Single and scattered gravels of the Scandinavian rock up to 10 cm in size. A sample from a depth of 4.8-4.9 m dated by the TL method to 244±36 ka (Lub—879).

$i_1$) 5.00 — 5.75 Light grey and bluish-greenish muds with yellow-rusty spots, in places with greyish-greenish sandy interbeddings; gradual transition; HCl-.

$i_2$) 5.75 — 6.35 Grey-dunnish clayey muds with dunnish-rusty spots; gradual transition; HCl-. A sample from a depth of 6.2-6.3 m dated by the TL method to 309±46 ka (Lub—881).

$j_1$) 6.35 — 6.65 Clayey-peaty mud, dark grey-dunnish, with weakly visible stratification traces; limit not sharp.

$j_2$) 6.65 — 6.75 Peat, very strongly compacted, dark grey-dunnish, friable and flaking off lamellarly; gradual transition.

$j_3$) 6.85 — 6.80/6.85 Peaty gyttja grey-brown coloured; gradual transition.

$k_1$) 6.85 — 7.60 Grey-brown coloured clayey mud passing to grey-greenish with dunnish-rusty spots. A sample from a depth of 7.0-7.1 m dated by the TL method to 337±50 ka (Lub—882).

$k_2$) 7.60 — 8.60 Grey-beige mud.

$k_3$) 8.60 — 9.00 Dark grey mud.

$k_4$) 9.00 — 9.50 Steel-grey clayey mud.

$k_5$) 9.50 — 9.80 Compact steel-grey clayey mud.

l) 9.80 — 10.30 Sands sliding off the auger (saturated with water).

A comparison of the exposures 1 and 2, distant only 20 m, indicates that some differences of the lithological features are distinctly connected with the present microrelief (decalcification of layers c – e in exposure 2 may be connected with axial position in the trough-like valley). Thus, with the older microrelief we can connect some differences in the formation of series of lacustrine deposits, i.e., particularly of layers i – k. A very distinct influence of the older microrelief was found in another section of the collector ditch at a distance of 300 m south-south-eastwards from exposures 1–2. The latter section of the collector ditch is connected with the interfluve zone of the Wieprz and Świnka rivers, elevated a little higher, which was beyond the range of lacustrine accumulation. However, in it layers stratigraphically preceding lacustrine accumulation were exposed.

Exposure 3

It is situated 178.5 m a.s.l. within a convex sloping relief form with a very small surface decline. The exposure from 0 to 7.3 m on the escarp of the ditch.

a) 0.00 — 0.20 Silty-sandy arable layer.

b) 0.20 — 1.00 Silty-loamy illuvial horizon, and below silty-sandy, brown and yellow-brown in the lower part with distinguishable darker and lighter streaks; gradual transition.

$c_1$) 1.00 — 1.20 Silty-sandy deposit, spotty, light dunnish-yellowish; border readable — decalcification limit.

$c_2$) 1.20 — 1.65 Silty-sandy deposit, light grey-yellowish, stratified-streaked subhorizontally; gradual transition; HCl+.

d) 1.65 — 1.95 Silty and silty-loamy horizon of weak gleyization with sandy-silty interbeddings, light grey-bluish and bluish-yellowish; gradual transition; HCl+. In some interbeddings fine chips of marl.

$e_1$) 1.95 — 2.60 Silty-sandy and sandy-silty deposit stratified subhorizontally, light grey-dunnish and grey-yellowish; in places a few marl chips; HCl+ (layers with a larger sand admixture do not react).

$e_2$) 2.60 — 3.00 Similar deposit but with a higher percentage of silty layers coloured light grey-bluish; HCl+. From 2.8 a vertical fissural structure reaching layer $e_4$ — pseudomorph after a frost crack with primary, seasonal mineral infilling.

$e_3$) 3.00 — 3.25 Silty-sandy deposit with sandy interbeddings, coloured lighter than at $e_2$; HCl+.

$e_4$) 3.25 — 4.30 Similar deposit as at $e_2$; gradual transition to $e_5$ or distinct limit separating from $f_1$.

$e_5$) 4.30 — 4.30/4.50 Discontinuous bed of stratified silty and silty-sandy deposits, grey and light grey; HCl+.

$f_1$) 4.30/4.50 — 4.30/4.65 Discontinuous sandy and sandy-silty horizon, yellow-dunnish-rusty with grey interbeddings — probably in the most part denudation products of the underlying soil.

$f_2$) 4.50/4.65 — 4.80/5.00 Grey silty-sandy humus horizon truncated by erosional surface. In its upper part signs of stratification-streaking and sandy interbeddings coloured lighter; below gradual transition; HCl- (in places nodule concentration of secondary carbonates). Cut by a distinct fissural structure reaching layer g; at the top its width is up to 10–15 cm, and the infilling with material from layer $f_1$ indicates that it is pseudomorph of polygonal cracks developing in conditions of strongly developed seasonal frost (a fissure with primary mineral infilling).

$f_3$) 4.80/5.00 — 5.20/5.35 Silty and silty-sandy horizon of weak leaching, ashen grey, spotty, with distinct pseudomorphs of foliaceous structure of fibrous ground ice; gradual transition; HCl-.

g) 5.20/5.35 — 5.80/6.10 Muds — light grey-greenish, indistinctly stratified, streaked in the upper part, downwards more sandy with distinct interbeddings of bluish-yellowish fine and medium sands with single gravels of the Scandinavian rocks. Lower layers with disturbances of the load casts type. Lower limit distinct but irregular.

$h_1$) 5.80/6.10 — 6.20/6.30 Discontinuous bed of irregularly layered (solifluctionally?) sandy-loamy deposits, grey-dunnish and grey-bluish, with single gravels of weathered Scandinavian rocks up to 4 cm in size; distinct limit.

$h_2$) 6.20/6.30 — 7.30 Glaciofluvial vari-grained sands with considerable admixture of silt and a few gravels mostly of weathered Scandinavian rocks, stratified largely subhorizontally, light grey-dunnish and yellowish-greenish.

Exposure 3A

Situated at a distance of about 25 m north-north-eastwards from 3. In the bottom of the ditch the following deposits underlying glaciofluvial sands came into view:

i) 8.00 — 8.50 Loamy and loamy-sandy deposit, ashen grey and grey-steel with numerous dunnish-rusty streaks in the net of irregular cracks; in places creeping structures are outlined; HCl-.

j) 8.50 — Weathering waste of marly limestones of upper Maestrichtian.

Thus, several discontinuities and stratigraphic gaps appear in exposure 3 at a depth of 4.3–6.3 m. They make difficult the interpretation and attempt at correlation with exposures 1–2. These discontinuities occurred in consequence of erosion developing in conditions of diversified microrelief, including probably karst, which was connected with bed rocks of upper-Maestrichtian age. Karst relief, reproduced in Quaternary deposits covering these rocks, was visible in the exposures 4 situated several dozen of metres south-westwards from 3. On this fossil surface of reproduced karst, forest soils of brown leached type or podzolic ones were developed. Within convex elements of the fossil relief, the upper horizons of this soil partially truncated, and in depressions denudation products up to 2.5 m thick occurred. The profile of this soil together with the parent rocks was studied in exposure 4A within a convex element of the fossil surface.

Exposure 4A

It is situated about 80 m south-westwards from 3 at a height of 179 m a.s.l. The top layers are removed or buried due to earthworks. The exposure is described at a depth from 4.8 to 8.0 m. The top layer examined was parallelized in 1984 with the lower layers e of exposure 3; it was also denoted by the letter e. However, that parallelization with exposure 3 is not easy because of the occurrence of erosional breaks.

e) 4.80 — 5.70 Silty-sandy deposit, light grey-yellowish with thin sandy interbeddings; sharp lower limit - erosional; HCl+.

$f_1$) 5.70 — 6.00 The upper part of humus horizon with signs of layering-streaking, silty-loamy, grey and grey-dunnish, with single pebbles of the Scandinavian rocks; gradual transition: HCl- (small aggregations of secondary carbonates occur).

$f_2$) 6.00 — 6.20/6.35 The lower part of humus horizon is coloured lighter, ashen grey-dunnish, fine-grained; gradual transition; HCl- (signs of occurrence of secondary carbonates). In the lower part zoogenic structures occur ("krotovines") filled with material from underlying horizons. A sample from a depth 6.15–6.25 m dated by the TL method to 279±41 ka (Lub—880).

$f_3$) 6.20/6.35 — 6.30/6.40 Horizon of weak leaching, light grey-dunnish and yellowish, marbled spotted; gradual transition; HCl-.

$f_4$) 6.30 —6.80/6.90 Sandy-loamy upper and middle part of illuvial horizon with single pebbles of the Scandinavian rocks, brown and rusty-brown, strongly spotted with relatively numerous "krotovines"; HCl-. Numerous pebbles of the Scandinavian rocks occur in the floor, which are scattered on the erosional surface (denudation pavement).

$f_5$) 6.80 — 7.20/7.30 The lower part of browning horizon coloured lighter, developed on sandy-loamy deposits with gravels, which have partially preserved the primary stratification structure; gradual transition.

g) 7.20 — 7.20/7.50 Discontinuous bed of weakly sorted sandy-loamy deposits with gravels, irregularly fluidaly stratified.

h) 7.20/7.50 — Glaciofluvial sandy deposits with a few pebbles, greyish-yellowish, subhorizontally stratified. A sample from a depth 7.4–7.5 m dated by the TL method to 352±53 ka (Lub—883).

Forest soil (type $A_1$–$A_2$–B–C), in identical stratigraphic position as in exposure 4A, was seen also in another section of the collector ditch built in 1986, which was distant 850 m south-south-westwards from points 3–4. In a considerable part of this ditch section there were visible over this soil up to 2 m thick covers of denudation products of its particular horizons originating from the neighbouring relief forms located a little higher. To illustrate this, we describe one of the exposures:

Exposure 5

A point on the eastern side of the sloping rampart extending across the interfluve of the Wieprz and Świnka rivers (see Fig. 2A, sign 18) at 178 m a.s.l., the nearest culmination point of the rampart — at a distance of about 150 m west-south-westwards — is 181.6 m a.s.l. The description is based on studies of the exposure in the excavation.

a) 0.00 — 0.15 Silty-sandy arable layer.

b) 0.15 — 0.90 Silty-sandy illuvial horizon, yellowish-brown, downwards with lighter streaks, readable limit — decalcification limit.

$c_1$) 0.90 — 1.50 Sandy-silty deposit, yellowish; gradual transition; HCl+. A sample from a depth 0.95–1.05 m dated by the TL method to 19±3 ka (Lub—1361).

$c_2$) 1.50 — 1.90 Fine and medium sands with silty interbeddings, light grey-yellowish; HCl+(in silty interbeddings). Distinct limit.

d) 1.90 — 3.40 Sandy and sandy-silty deposits irregularly stratified-streaked, ashen grey and light dunnish and yellow-rusty, spotted; distinct limit or almost gradual transition; HCl-. These are denudation products of burried soil similar to that occurring lower in this profile (layers e – f), displaced on the slope by solifluction. Such a transport is testified not only by the stratification character, but also detaching considerable assize of these deposits, in places distinctly readable.

$e_1$) 3.40 — 3.55/3.65 Humus horizon light grey-dunnish, sandy-silty; gradual transition. In places this horizon shows signs of solifluctional disturbance.

$e_2$) 3.55 — 3.70/3.80 Horizon of distinct leaching and podsolization, ashen grey with spots and yellow-rusty streaks, gradual transition.

f) 3.70/3.80 — 4.30 Illuvial sandy horizon with single gravels of the Scandinavian rocks, grey-yellowish-brownish, with differentiated granulation and colouring; gradual transition. In this horizon, and also in the overlying ones relatively numerous "krotovines" occur in places. In its lower part or in the floor there is erosional surface with scattered gravels of the Scandinavian rocks (denudation pavement).

g) 4.30 — Glaciofluvial vari-grained sands with scattered pebbles of the Scandinavian rocks, alternately but distinctly stratified.

Exposure 5A

Glaciofluvial deposits occurring below the buried soil were best exposed and accessible for detailed examination, on the opposite wall of the ditch, at a distance of 20 m south-eastwards from point 5.

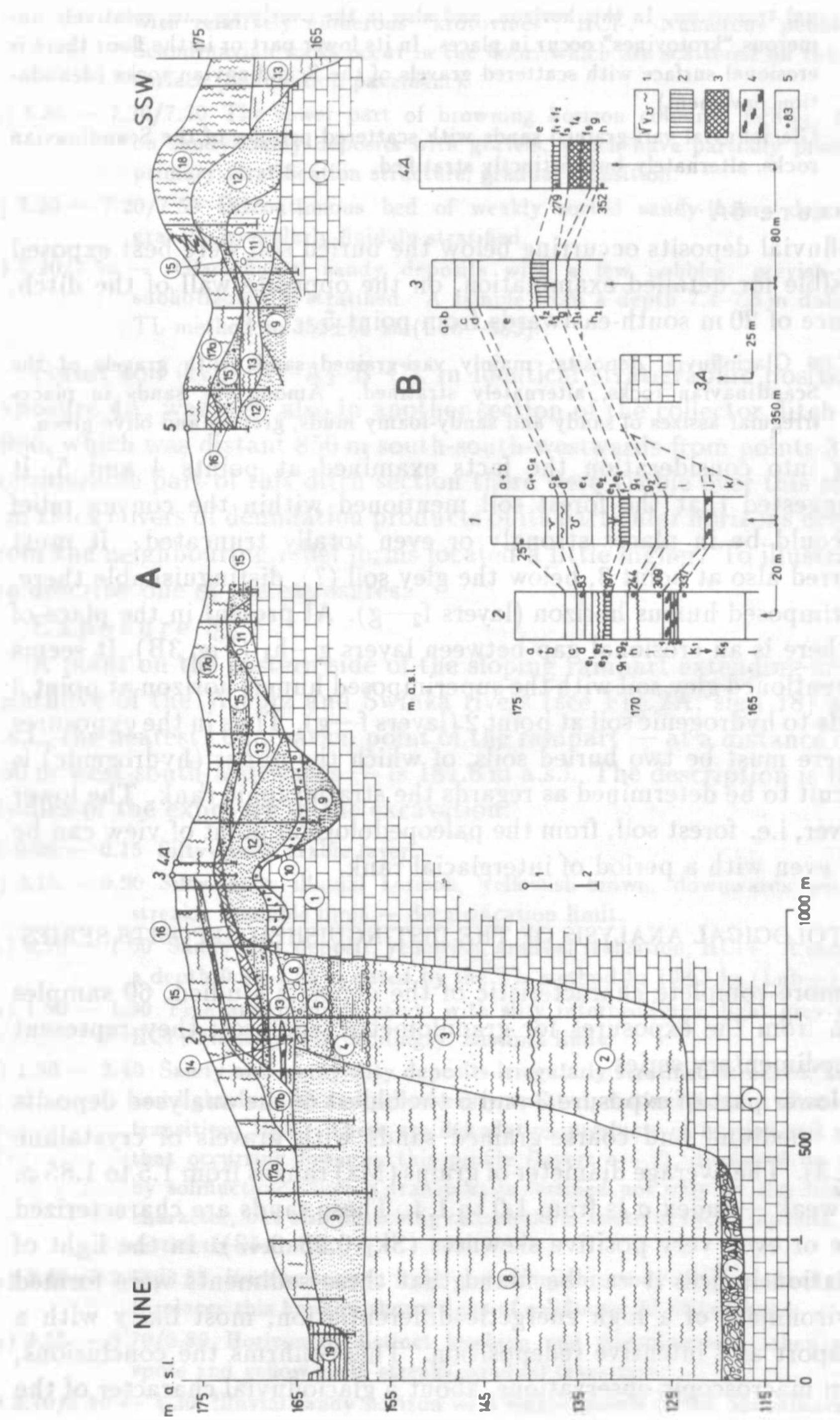
g) 4.30 — 7.00 Glaciofluvial deposits; mainly vari-grained sands with gravels of the Scandinavian rocks, alternately stratified. Among the sands in places irregular assizes of sandy and sandy-loamy muds, greyish and olive-green.

Taking into consideration the facts examined at points 4 and 5, it can be suggested that the forest soil mentioned within the convex relief elements could be in places strongly or even totally truncated. It must have occurred also at point 3, below the gley soil (?), distinguishable there, with superimposed humus horizon (layers $f_2$—g). At present in the place of this soil, there is an erosional gap between layers g—$h_1$ (Fig. 3B). It seems that the mentioned gley soil with the superimposed humus horizon at point 3 corresponds to hydrogenic soil at point 2 (layers f—g). Thus in the exposures studied there must be two buried soils, of which the upper (hydrogenic) is more difficult to be determined as regards the stratigraphic rank. The lower one, however, i.e. forest soil, from the paleopedological point of view can be connected even with a period of interglacial rank.

## SEDIMENTOLOGICAL ANALYSIS OF THE DISTINGUISHED DEPOSITS SERIES

For a more complete characteristic of the deposits studied, 60 samples were taken from the exposures for granulometric analyses; they represent the main sedimentary series.

In the lower part of exposure 3 and 5 the oldest of the analysed deposits occur, i.e. medium- and coarse-grained sands with gravels of crystalline rocks (Fig. 3). The average diameter of grains (Mz) ranges from 1.5 to 1.85 $\phi$. Sorting is weak — index $\sigma$ is from 1.0 to 1.4. These sands are characterized by positive or even very positive skewness ($Sk_1$ 0.25–0.43). In the light of the granulation indices it can be found that these sediments were formed in the environment of a high energetic differentiation, most likely with a short transport and intensive redeposition. This confirms the conclusions, drawn from macroscopic observations, about a glaciofluvial character of the sediment.


A
B
NNE
SSW
m a.s.l.
0
500
1000 m
20 m
25 m
80 m
350 m
1A
2
3
4A
3A

Stratigraphically overlying deposits, in relation to glaciofluvial sands, are sands and muds (layers k - l in fig. 3B), drilled at the foot of exposure 2, for which granulometric analyses were not done. To the next series analysed belonged silts occurring above peats (layers $j_1 + i$). These deposits are characterized by indices Mz ranging from 6.0 to 5.5 $\phi$. A distinct tendency of the grain size to increase towards the top is observed, and sediment sorting is worsening in the same direction ($\sigma$ 1.77–2.33). Grain-size distribution, however, is almost symmetric, and in the top layers index $Sk_1$ is slightly negative (-0.04), which accounts for the sediment enrichment with coarser fractions. The organogenic sedimentation phase ($j_3 + j_2$) was followed by a slow infilling of the lake reservoir in conditions of lacking flow. In the upper part of the sediments filling the reservoir ($i_1$), signs of flow can be observed, probably periodical. This is indicated by sandy interbeddings containing over 4% of grains below 1$\phi$ in diameter.

Mud deposits are truncated by the erosional surface on which vari-grained sands with gravels and pebbles of the Scandinavian rocks lie (Fig.3B, layer 2 h). They are sorted very weakly ($\sigma$ 2.4) with strongly positive skewness indicating sedimentation in streamless environment. They can be interpreted as deposits of colluvial type (sediment of solifluctional flow?).

Fig. 3. Geologic cross-section of Wieprz and Świnka interfluve and lithological schemes of the investigated exposures (worked out by M. Harasimiuk 1988)

A. Geologic cross-section east of Łęczna along the line denoted on in Fig. 2. Explanation of the marks: 1 — investigated outcrops (1 - 5); 2 — boreholes documented by different institutions. Explanation of indexes (numbers in circles) of lithostratigraphic layers: 1 — upper-Cretaceous marls; 2 — Eopleistocene laminated muds and sandy muds; 3 — Eopleistocene fine sands and laminated sandy muds (2 and 3 Krasnystaw series after J.E. Mojski 1985); 4 — middle Pleistocene sands and clayey sands; 5 — middle Pleistocene medium and coarse sands; 6 — older tills (Sanian=Elsterian II); 7 — coarse gravels of crystalline and local upper-Cretaceous rocks (Sanian); 8 — muds and sandy muds horizontally laminated (Mazovian=Holsteinian); 9 — medium grained sands (Mazovian); 10 — colluvial loams with strongly weathered crystalline rocks and regolith of upper-Cretaceous rocks (early Odranian); 11 — younger tills (Odranian=Saalian I); 12 — glaciofluvial sands (Odranian); 13 — muds (inter-Saalian); 14 — peats and peaty muds (inter-Saalian); 15 — colluvial loamy sands with crystalline gravels (inter-Saalian and early Wartanian); 16 — fossil soils (inter-Saalian and early Wartanian); 17 — silty sands and sandy silts (Wartanian=Saalian II and Vistulian); 18 — gleyed sandy silts (Vistulian); 19 — loesses (Vistulian); 20 — alluvial deposits (Holocene). B. Correlation of lithological-stratigraphical schemes of investigated exposures: 1 — disturbances of layers (cryogenic and dessication fissures, load casts types and solifluction); 2 — fossil soils of younger generation; 3 — fossil soils of older generation; 4 — organogenic deposits; 5 — TL age in ka

Of a similar character is the deposit lying on glaciofluvial sands in exposure 3 (layer $h_1$).

On colluvial sediments there occur fine-grained deposits in exposure 2 ($g_1 + g_2$) and 3 (g). They are also weakly sorted (Mz 5.5 – 5.6 $\phi$; $\sigma$ 1.73 – 2.13). They can be defined as colluvial-deluvial. In the area of exposure 1 and 2 distinct traces of leaching occur in the top of these deposits, which is marked by increased sorting and decreased positive skewness coefficient of granulation from 0.42 to 0.29.

Granulometric analyses of the distinguished horizons of fossil soils (layers f in exposures 1–3 and 4A) showed a big variation of Mz index ranging from 3.3 to 5.6 $\phi$, very weak sorting ($\sigma$ 1.7–1.9) and positive skewness. Analyses of these layers do not allow us to determine what should be associated with the primary features of the sediment, and what with pedogenesis (epigenetic).

The fossil soil is covered with a complex of silty-sandy or sandy-silty deposits differentiated structurally and texturally both horizontally and vertically. In the area of exposures 1 and 2 the lower part of this complex (layers $e_2$ – $e_4$) is formed by muds characterized by index Mz 5.4 $\phi$, very positive skewness and weak sorting ($\sigma$ 1.85). Upwards the content of sandy material increases, which is marked by Mz increase up to 3.45 $\phi$; however, the sorting degree becomes worse. Characteristic is also the occurrence of drying cracks. The top part is characterized by further increase of sand fractions (Mz 1.71 $\phi$), improvement of sorting ($\sigma$ 1.2), decrease of the skewness index to 0.19. The character of these changes points to the growing role of water flowing in the sedimentation. This conclusion is compatible with the stratification type and the occurrence of disturbances of load casts type, giving evidence of a strong water saturation of the sediment.

A different character is shown by sediments which stratigraphically correspond to layers 1e and 2e in exposure 3 situated outside the depression (denudation valley?). Two silty layers ($3e_2$ and $3e_4$) were distinguished in the complex of sandy-silty deposits. In these layers the content of silt fraction reaches 36%, and silty-sandy (0.05–0.1 mm) 49%. They are characterized by Mz indices ranging from 4.45 to 4.63 $\phi$, weak sorting and very positive skewness. These features point to a small role of water in sedimentation, and a considerable role of the eolian factor. The occurrence of pseudomorphs of the frost fissures confirms the thesis about a relative dryness favouring the development of eolian processes. Layers $3e_1$ and $3e_3$ are characterized by distinctly coarser grains (Mz about 2.75 $\phi$), predominance of fraction 0.1–0.25 mm (up to 50%), a little better but still weak sorting ($\sigma$ 1.2) and by a distinct decrease of the skewness index to 0.15. These features as well as distinctly readable subhorizontal stratification point to increased significance of water flowing in the sedimentation process. These could be slowly flowing flood waters, or seasonal waters on gently inclined, long slopes.

Despite some differences resulting from the peculiarity of the morphological situation, the deposits in exposures 1–2 and 3 can be interpreted as genetically similar and included in deposits of deluvial types.

In all exposures studied a gleyization horizon about 0.3 m thick is found on deluvial deposits. In relation to the underlying layers, it is characterized by distinctly finer grains (Mz 4.4–5.04 $\phi$), worse sorting ($\sigma$ to 1.76), and the transition to the highest class of positive skewness ($Sk_1$ over 0.3). A similar thickness of the horizon and characteristic bluish colouring indicate that different features of the granulation of this sediment are connected rather with epigenetic processes than with changed sedimentation conditions.

Above the gleyization horizon and below the present soil there occur sandy-silty deposits. In the region of exposures 1 and 2 these are deposits with a little finer grains (Mz 4.4–4.6 $\phi$) than in the region of exposure 3 (Mz 3.1–4.4 $\phi$). The sorting degree and skewness indices are similar ($\sigma$ about 1.4–1.5, and $Sk_1$ 0.2–0.4). These deposits are genetically similar to those occurring below the gleyization horizon. A considerable content (30–37%) of silt fractions 0.05–0.01 mm points to the supply of material of eolian origin. In the zone of distinctly raised ramparts, particularly along the Wieprz river valley, these deposits pass to proper loesses (Fig. 3A).

## POLLEN ANALYSIS

In exposure 2, samples were taken for pollen analysis from two depth intervals: from horizons of buried soil (depth 3.70–4.65 m) and boggy-lacustrine deposits (depth 5.0–10.3 m).

The boggy-lacustrine series occurring between sand horizons is about 4.7 m thick. For pollen analysis several dozen samples were taken: from gyttja and peat every 2–5 cm, and from mud and clay on the average every 10 cm. It should be stressed that to the depth of 7.6 m the samples came from the exposure, and from 7.6–10.3 m from drilling. The results of pollen analysis are not equal for this series. Lower clayey muds and beige muds (Fig. 4, samples 20–23 from a depth 8.6–9.6) are characterized by a high frequence of pollen, grains are well preserved. Pollen spectra are distinguished by a high content of Tertiary sporomorphs and marine plankton. Such a big admixture of foreign elements in Quaternary sediments is generally recorded in tills and glaciolacustrine sediments.

In the depth interval 8.0–8.5 m pollen occurred sporadically, the frequency of grains was very low (8.0–8.1 m).

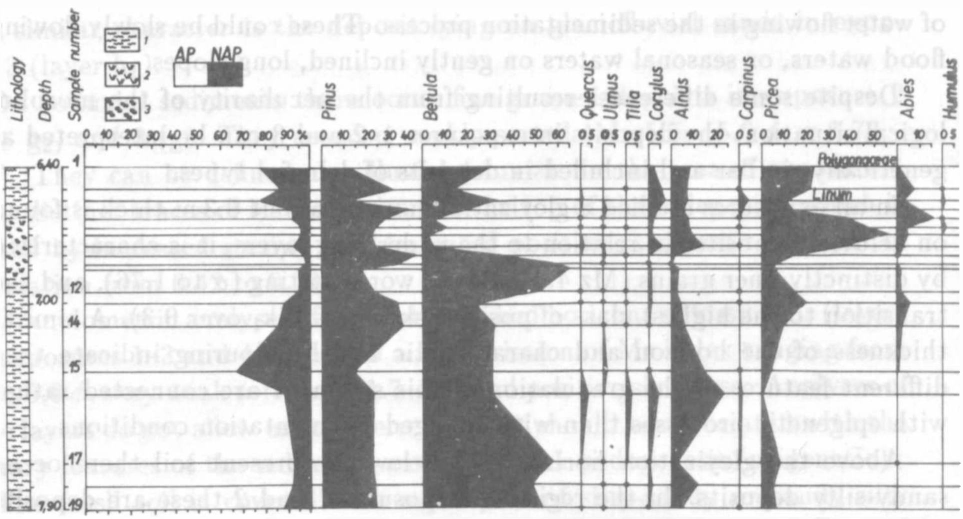


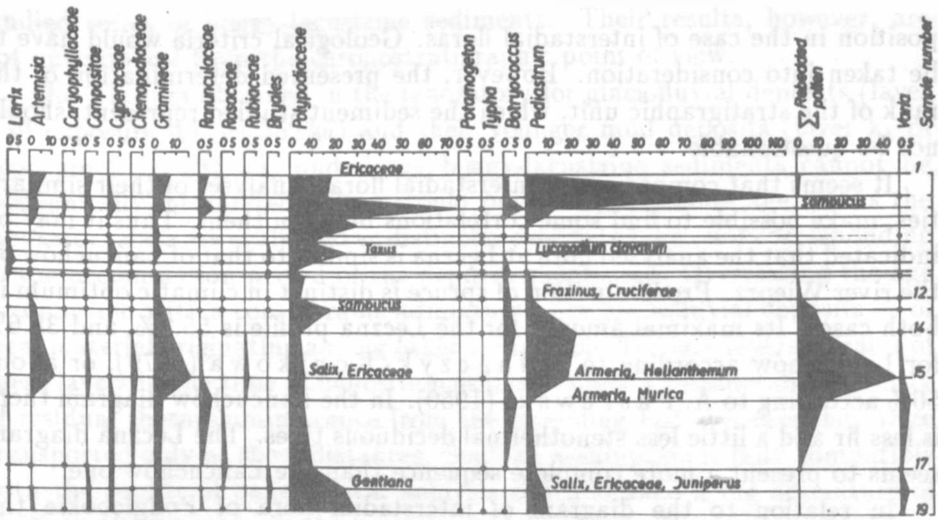

Fig. 4. Pollen diagram of layers $j_1$–$k_2$ of Lęczna 2 exposure (worked out by Z. Janczyk-Kopikowa 1988)

In samples from a depth 6.4-7.8 m pollen occurred again abundantly or very abundantly. In mud layers (6.85–7.90 m) grains were destroyed, some times very much; this may have resulted from weathering of the sediment. In gyttja and peat grains were well preserved, without weathering traces. However, in mud from the upper parts of the profile (6.4–6.8 m) pollen showed a strong destruction again.

The results of pollen analysis are shown in the pollen diagram (fig. 4). The calculation sum for the diagram is AP + NAP = 100 %.

The pollen diagram illustrates the development of vegetation from the occurrence of dense, boreal forests (7.4–7.9 m) of birch (*Betula*) and pine (*Pinus*) with an admixture of spruce (*Picea*) and alder (*Alnus*). In trace amounts there occurred stenothermal deciduous trees: oak (*Quercus*), elm (*Ulmus*), lime (*Tilia*), hazel (*Corylus*). The character of these forests is testified by about 10% content of herbaceous plants (NAP). In samples from higher parts (7.0–7.4 m) herbaceous vegetation was found to be richer (maximally up to 32.8%), which gives evidence of more loose communities and of existing open spaces with photophillic vegetation. The lack of dense forests caused by periodical coolness may have contributed to intensification of redeposition of the perisuperficial deposits. This is indicated by a considerable increase of Tertiary material in pollen spectra; the maximal content of Tertiary sporomorphs is 42.4% in the depth interval 7.0–7.4 m.

In the following phase the content of herbaceous vegetation (NAP) is



1 — mud; 2 — gyttja; 3 — peaty gyttja

small, about 5%, forest was a predominating community. Initially birch (*Betula*) predominated, reaching maximally 65.3%. Pine (*Pinus*), spruce (*Picea*) occurred too, in traces stenothermal deciduous and fir (*Abies*); also alder (*Alnus*) occurred. A consequent decrease in the amount of birch (*Betula*) is found when moor communities were expanding. The forest still preserved its boreal character with predominating coniferous elements. Spruce (*Picea*) started to predominate among coniferous, reaching maximally 55.2%. Such a content of spruce should be recognized as high. In that period a maximal content of fir (*Abies*) amounting 16% and stenothermal deciduous trees (*Quercus, Ulmus, Tilia* as well as *Corylus* and *Carpinus*) is also recorded. This community corresponding to moderately cool climate represented the climatic optimum of the sequence studied. Samples from the higher part of the profile record a decrease in the amount of spruce, fir and stenothermal deciduous trees. However, the amount of herbaceous plants (NAP) and birch (*Betula*) increased in them. Boreal forests returned in this area. Samples above 6.4 m contain pollen grains only sporadically.

The climatic optimum with dominating coniferous forest, having a moderately cool character, points unequivocally to the interstadial rank of the sediments analysed. Thus the climatic optimum in our profile, in its pollen sequence, has not an interglacial character.

According to the generally accepted opinion the method of pollen analysis itself is inadequate to ascribe sediments to a definite stratigraphic position in the case of interstadial floras. Geological criteria would have to be taken into consideration. However, the presented determination of the rank of the stratigraphic unit, which the sediment studied represent, should not be questionable.

It seems that comparison of interstadial floras, analyses of their similarities, make possible to find some correlations between them. Thus it may be indicated that the analysed flora at Łęczna is similar to that of Łańcuchów on the river Wieprz. Predomination of spruce is distinct in climatic optimum in both cases. Its maximal amount for the Łęczna profile is 55.2%, and 38.6% for Łańcuchów according to Z. Janczyk-Kopikowa (1979), or about 50% according to A. Paszewski (1950). In the Łańcuchów diagram there is less fir and a little less stenothermal deciduous trees. The Łęczna diagram seems to present a more complete sequence than the Łańcuchów one.

In relation to the diagram of interstadial flora of Podgłębokie the discussed one of Łęczna is less complete. Tundra spectra are absent in it, which are observed in the lower and upper parts of the Podgłębokie profile. However, the character of forests in climatic optimum is approximate in both stands. The content of spruce at Podgłębokie reaches about 40%, and that of fir maximally 19.5%. The amounts of alder and stenothermal deciduous are similar in both stands.

The compared floras of Łęczna, Łańcuchów and Podgłębokie can thus be correlated in respect to age because there are no contraindications from the point of view of geology. The floristic similarities are big.

In samples taken at Łęczna from a depth of 3.70–4.65 m, i.e. representing the horizons of buried soil, despite triple maceration with various methods no traces of pollen material were found. However, by the flotation method spicules of sponges were separated, which formed a homogeneous residuum. It can be stressed that no traces of diatoms* were found at the same time.

## CHRONOSTRATIGRAPHIC AND PALEOGEOGRAPHIC INTERPRETATION

Our TL datings confirm the conclusion, resulting from an analysis of the geologic-morphological situation, about the pre-Vistulian age of the

* The occurrence of sponge spicules in preparations made from samples taken in the discussed profile at a depth of 3.70–4.65 m, was confirmed by Prof. S. W. Alexandrowicz (Academy of Mining and Metallurgy in Kraków), and by Dr. W. Przybyłowska-Lange (from the State Institute of Geology in Warszawa). According to Dr. W. Przybyłowska-Lange the lack of diatoms may be interpreted by the fact that they are less resistant to destructive factors than sponge spicules. If diatoms originally occurred they may have dissolved at a high pH of the environment, or in conditions of dry climate. We are thankful to Dr. W. Przybyłowska-Lange and Prof. S. W. Alexandrowicz for checking our preparations and their kind help with the interpretation of the analysis results.

studied series of boggy-lacustrine sediments. Their results, however, are not unequivocal from the chronostratigraphic point of view.

The TL data obtained in the laboratory for glaciofluvial deposits (layer h of exposure 4A — 352 ka) and their younger mud deposits (layer $k_1$ of exposure 2 — 337 ka) underlying boggy-lacustrine sediments cannot be mechanically interpreted. They would point to pre-Saalian age. Thus the laboratory data are evaluated as distinctly overstated, i.e., not corresponding to the accumulation period of the deposits mentioned. Overstating the age is connected with a considerable admixture — in glaciofluvial deposits — of local material originating among other things from Tertiary layers. Grains of these layers in the time of deposition still contained a considerable quantity of residual thermoluminescence from the preceding bed, because they were transported only at short distances. Such an assumption is fully compatible with the results of palinological analysis which showed a big admixture of Tertiary sporomorphs in the layers underlying boggy-lacustrine ones.

On such initial evaluation of the results of TL dating we can assume that our glaciofluvial sediments must represent older stadials of the Odranian glaciation. For the stadial of the maximal extent of Odra inland ice, according to TL chronology, time interval 280–270 ka has recently been established, and 270–260 ka for the first post-maximal stadial (L. Lindner et al. 1985, M. Harasimiuk et al. 1988). The studied area was within the extent of this inland ice during both stadials. Over the second post-maximal stadial, dated to about 250 ka, the terminal moraine zone of the inland ice was running 15–20 km north of Łęczna.

The lower limit of the accumulation period of boggy-lacustrine sediments may thus be dated at the latest to about 240 ka. The forest vegetation which occupied the environs of the lake may have developed fully only then when the inland ice retreated at a much greater distance than during the second post-maximal stadial. Accordingly, the forest phase of the landscape development should be connected with the period of inter-Saalian warming up, separating the Odranian (=Saale I) and Wartanian (=Saale II) glaciation. This period is distinguished in SE Poland as Lublinian (=Treenian = Odintsovian) interglacial, and according to latest stratigraphic schemes of the Quaternary in Poland, elaborated by L. Lindner (1988), as Grabówka or Lubawa interglacial. According to the TL chronology of Polish loesses the time limits of this period were determined to 235–225 ka (H. Maruszczak 1987).

The upper limit of the accumulation period of boggy-lacustrine sediments may be defined to 210–205 ka on the basis of TL datings of samples from the Łańcuchów section. These are archival samples taken in 1967 by

H. Maruszczak from the exposure ("Łęczna" 34), which was examined paleobotanically by Z. Janczyk-Kopikowa (1979). The TL age of the sand samples taken at 0.3 m below the lower peat (peat layer from 9.00 to 9.15 m according to Z. Janczyk-Kopikowa) is 209±31 ka (Lub—1659). Mud samples taken at 0.3 and 0.9 m above upper peat (peat layer from 8.25 to 8.75 m according to Z. Janczyk-Kopikowa) were dated by TL method to 206±30 ka (Lub—1657) and 200±30 ka (Lub—1656), respectively. It can be stressed that the boggy-lacustrine series from Łańcuchów occurs within the bottom of the wide Wieprz river valley. Thus, mineral grains were transported by this river during a long time before deposition in the alluvial lake (oxbow). Therefore, its TL age is undoubtedly not very distant from the deposition time.

In the boggy-lacustrine accumulation period in depressions, the neighbouring elevations built from glaciofluvial deposits were covered with forests in which brown or pseudopodzolic soils developed (layers $f_4$–$f_5$ in exposure 4A). These soils should also be correlated with the interval 235–225 ka. The laboratorially determined TL age of the sample from humus horizon superimposed on the profile of such a soil (layer $f_2$ in exposure 4A — 279 ka) does not contradict such an interpretation. It may be overstated for the reasons already defined. It refers to mineral grains of cover sediments accumulated on erosional surface — marked by a layer of gravel pavement — truncating glaciofluvial deposits. These cover deposits, undoubtedly of eolian genesis, represent degradation products of Odranian sediments, or also of Tertiary sediments which occurred in the closest vicinity. Thus the grains of the cover deposit may have contained a considerable quantity of residual thermoluminescence.

Younger than the cover eolian deposits included in forest soil horizons are upper lacustrine muds, which were accumulated in depressions after the period of the development of bogs inside forests. These lacustrine muds are a correlative sediment of slopes denudation which developed in connection with the appearance of open spaces with herbaceous vegetation in the landscape. In that time deposits of the preceding degradation phase of Odranian sediments were denudated. In this connection grains of upper lacustrine muds — after several weathering and redeposition cycles* — had a smaller quantity of residual thermoluminescence. Therefore, the TL age of the sample taken from the humus horizon developed on lacustrine muds

* The fact that the layers of upper lacustrine muds underwent a stronger weathering and degradation is, among other things, accounted for by the lack of plant remains.

(layer f from exposure 2 - 197 ka), corresponds more to the accumulation period of these deposits.

We can present now an attempt of systematic chronological arrangement of episodes recorded in the exposures described. It should be stressed that we accept here thermoluminescence chronology of Mesopleistocene in Poland established largely on the basis of studies of typical eolian loesses, i.e. deposits most suitable for dating by the TL method. This chronology in its principle features is convergent with the chronology of isotope-oxygen stages, established on the basis of results of datings with various methods (H. Maruszczak 1987). Due to that it can be attempted to correlate the episodes recorded in the environs of Łęczna with a curve of changes of $^{18}O$ content in deep-sea sediments, which is accepted as the basis of reconstruction of climatic rhythms in a global scale. From among the appropriate schemes we have chosen that developed by J. Imbrie et al. (1984), which seems to be at present the most universal and detailed. For all stages and substages distinguished in this scheme the averaged age in thousands of years has been given according to "SPECAM time scale".

The glaciofluvial sediments of the Odranian (=Saalian I) inland ice occurring in our area can be parallelized with substages 8.4 (269 ka) or 8.2 (249 ka). The datings of these isotope-oxygen substages are relatively distinctly convergent with TL chronology established for loesses and glacial sediments in SE Poland.

Degradation of these sediments marked with erosional surface with pavement and with eolian accumulation (?) of cover deposits occurred in the periglacial zone in the foreland of the retreating Odranian inland ice. In a little later Odranian phases, with disappearing permafrost, thermokarst depressions were formed and denudation products were accumulated in their bottom. These events should be parallelized with substages 8.1 and 8.0 (245 ka), and probably also with 7.5 and 7.4 (238-228 ka). It can be stressed that in the light of TL datings of Polish loesses the paleogeographic conditions of the interval corresponding to substage 7.5 were not quite clear. This interval should be included rather in the later Odranian (isotope-oxygen stage 8) than in the warming up period between Odranian = Saalian I and Wartanian = Saalian II (stage 7).

In the subsequent phases boggy-lacustrine sediments were accumulated in the bottom of depressions, and on elevations well-developed brown or pseudopodzolic soils were formed. In conditions of moderate climate of a cool variety our area studied was covered with dense forest communities. The optimal development phase of such communities should be parallelized with substage 7.3 (216 ka), i.e., the warmest in stage 7. The age determined for this stage in the global scheme (J. Imbrie et al. 1984) is by about 10 ka later than that in TL chronology accepted by H. Maruszczak (1987a) for a well-developed soil separating middle older loesses from upper ones. It seems that this difference can be estimated as relatively small. However, it is totally involved in the technical error of TL dating by the method accepted.

Partial (exposure 4A) or total (exposure 3) denudation of the forest soil mentioned, and accumulation of denudation products in a reactivated lake in a land depression should be connected with substage 7.2 (205 ka). This substage should also be connected with the development of hydrogenic (gley) soils in phases of weakened denudation processes. The reconstructed events seem to indicate that in this substage the climate was relatively humid and cool; "open" areas occurred in the landscape.

The formation of turfy humus horizons — superimposed on hydrogenic soils in depressions and preserved parts of the profile of forest soils on elevations — is parallelized with substage 7.1 (194 ka). Thicker humus horizons superimposed on forest brown soils, or degraded chernozems correspond to them in loess profiles. According to H. Maruszczak (1987b) with these intraloess soils there are associated pseudomorphs of crack (frost and desiccative) polygons, which developed most likely in the forest-steppe zone in conditions of continental climate with mean annual temperatures of about 1 to 2°C. It may be that the humus horizons discussed should already be associated with one of the earliest phases of the Wartanian (=Saalian II) glaciation cycle. In such an interpretation they would constitute a paleogeographic homologue of early-Vistulian humus horizons superimposed in substages 5.4 and 5.3 on Eemian forest soils (substage 5.5), which commonly occur in loess profiles in Poland.

In the following substages, i.e. 7.0 and 6.6 (186–183 ka), polygenetic soils developed earlier, particularly the soil complex comprising brown forest soil and a humus horizon superimposed on it, already underwent a strong degradation and denudation. This must have taken place in the periglacial environment, which is indicated by signs of solifluctional translocation of thick denudation products of the soil complex mentioned, very well preserved in exposure 5. These events and those younger than they, however, are less significant from the point of view of these investigations. Therefore, attention is given only to the fact that younger events are recorded in sediments of slope type (deluvial, colluvial) with possible presence of the eolian factor visible more or less distinctly. These are sediments which were formed in another geomorphological situation. In today's interfluve area of the Wieprz and Świnka rivers, the features of postglacial relief characterized, among other things, by the occurrence of depressions with lakes and bogs disappeared in that time. Thus, it was still in the Wartanian (=Saalian II) when features of erosive-denudative relief with a developed network of draining valleys appeared.

CONCLUDING COMMENTS AND DISCUSSION

1. The studied boggy-lacustrine sediments and fossil forest soils at Łęczna occur among the layers accumulated after the last phase of glaciofluvial sedimentation in the area, but before accumulation of loess-like perisurficial deposits. Their occurrence in this sequence confirms the results of initial analysis of the location of the studied site within an accumulation-denudation surface rising above a younger terrace of the Wieprz river dated to Plenivistulian.

2. The results of dating by the TL method indicate that glaciofluvial sediments underlying the boggy-lacustrine series should be connected with maximal or the first postmaximal stadial of the Odranian glaciation (=Saale I). Loess-like deposits, however, covering this series, represent the period of the last glaciation (i.e. Vistulian = Weichselian). Sediments and forest soils being the subject of our studies were formed in the postglacial landscape after the regression of the Odranian inland ice. According to the regional thermoluminescence chronology this took place in the interval 235–225 ka BP, i.e. in the period separating the Odranian and Wartanian glaciation (Saale I/Saale II).

3. Palinological analysis showed that boggy-lacustrine sediments were accumulated in conditions of moderate climate of a cool variety. The period of their accumulation, i.e. 235–225 ka BP according to dating with the TL method, should be parallelized with isotope-oxygen stage 7.3 of deep-sea sediments, recently dated to 215 ka BP. In the same period forest brown and pseudopodsolic soils were formed on elevations rising over boggy depressions. From the paleopedological point of view it could be assumed that these are soils of interglacial rank. In such an interpretation they would represent the Lublinian (=Treenian = Odintsovian) interglacial separating the Odranian and Wartanian glaciations. However, from the paleobotanical viewpoint the boggy-lacustrine sediments can be ascribed only the interstadial rank; a paleobotanist's opinion (Dr. Z. Janczyk-Kopikowa) is here unequivocal. Thus the results of our studies seem to confirm the opinions about the non-typic (transitional?) character of the paleogeographic conditions of the period separating the advancement of the inland ices Saale I and Saale II. Therefore, this period is defined as interstadial or interglacial (interglacial/interstadial) not only in Poland but also in the neighbouring regions of Europe (V. Ložek 1976, J. Macoun

1985, N. S. Čebotareva 1987). The belt of Middlepolish lowlands, in the optimal climatic phase of this period, may have remained in the extent of coniferous forests with an admixture of stenothermal deciduous trees (interstadial conditions). A zone of mixed and deciduous forest of the European type (interglacial conditions) may have occurred in that time in lower geographic latitudes, i.e. south of Poland. Such an opinion was expressed by H. Maruszczak (1987b) on the basis of analyses of soils occurring among older European loesses dated to 230–220 ka by various methods. Anyhow, it can be stressed that organogenic sediments with unquestionable interglacial features dated to this interval have not been found as yet in Poland's territory. In recent years, some results of studies of organogenic deposits with interglacial features were published. These deposits were correlated with the period separating the Odranian and Wartanian glaciation, but this opinion has caused much controversy. Thus, e.g., geologic-stratigraphic interpretation of the position of such sediments in the profile "Piła" is distinctly divergent from the results of studies of diatoms (opinion of B. Marciniak, vide S. Dąbrowski et al. 1987).

4. A thick humus horizon, connected with pedogenesis specific for turfy communities, was superimposed on the profile of the discussed fossil forest soils. They jointly form polygenic soil, or a soil complex which — with respect to typology and age — corresponds to the pedocomplex separating middle older and upper loesses in Poland and in the neighbouring regions of Europe (H. Maruszczak 1987a, b). The turfy-meadow horizon of this pedocomplex can be dated to about 200 ka according to the regional thermoluminescence chronology. The period of its formation would thus correspond to substage 7.1 of deep-sea sediments, dated to 194 ka. As in this humus horizon no plant remains have been preserved in the site studied, the paleogeographic conditions of its development are determined on the basis of paleopedological studies, taking into consideration the results of investigations of analogous horizons of intraloess soils. From such an analysis it appears that in the phase of advanced development of humus horizons, or in that following it immediately, mean annual temperatures ranged from 1–2°C. In such conditions well developed seasonal permafrost occurred, with which solifluctional and kryogenic disturbances were connected. Accordingly, the development phase of humus horizon may already be included in the early Wartanian (=Saalian II). The discussed soil complex is from paleogeographic viewpoint similar to the pedocomplex which was formed in the Eemian and early Vistulian. (H. Maruszczak 1987a). Taking into consideration these analogies it can be concluded that in Lublinian interval less developed forest soils occured (smaller thickness of

soil horizons, weaker signs of illuviation) than those which developed in our region in the Eemian. Such a conclusion seems to be fully compatible with the interpretation of paleogeographic conditions in Lublinian, presented in the preceding point.

5. Boggy-lacustrine sediments of the Lublinian in the Łęczna site are in regard to pollen sequence very similar to those studied earlier at Podgłębokie and Łańcuchów (Z. Janczyk-Kopikowa 1969, 1979). In the two sites they were determined as representing Brörup interstadial, which was confirmed by an analysis of the geological situation which corresponded to the opinions valid then. This interpretation should be corrected now, among other things because of the occurrence of Vistulian terraces in the Wieprz river gorge near Łęczna found in later years, and because of the results of TL dating for the Łańcuchów stand presented in this paper. On such a basis the organogenic sediments at Podgłębokie and Łańcuchów should now be recognized of the same age as those of the site at Łęczna.

6. The interval separating the Odranian and Wartanian glaciation, i.e. Intersaalian (=Saalian I/Saalian II) is consequently determined as Lublinian (=Treenian = Odintsovian). The first who proposed such a determination for this interval in Poland was A. Środoń (1969). This proposition was accepted and applied in the later worked out stratigraphic schemes of Pleistocene in Poland (e.g. S. Z. Różycki 1980, M. Harasimiuk et al. 1988), despite the critically evaluated qualification of sites of organogenic sediments analysed by A. Środoń, which were to represent this period. In recent years only L. Lindner (1984, 1987, 1988) has presented other terms in his schemes, ascribing this period features of typical interglacial (Grabówka interglacial, Lubawa interglacial). He mentioned in them various sites of organogenic sediments, studied palinologically, as "stratotype" for this interglacial (Grabówka, Losy, Tomaszów). The published descriptions of the stratigraphic position of these sediments raise some doubts, which were drawn attention in point 3. Thus, it seems that the results of datings by the TL method is the main basis for connecting these various sites and correlating them with the period separating the Odranian and Wartanian glaciation. These results are treated too mechanically, without interpretation similar to presented in this paper. It is particularly unjustified to make such correlations on the basis of dating results from various TL laboratories, which use significantly different analytical procedures (H. Maruszczak 1985). Due to the commonly known big differences of dating results of the same samples in various laboratories, which are documented in publications (e.g. A. Bluszcz 1989) such a way of documentation of stratigraphic units must give rise to controversy.

## REFERENCES

Butrym J. 1985, Application of the thermoluminescence method to dating of loesses and loesslike formations. Guide-book int. symp. "Problems of the stratigr. and paleogeogr. of loesses", UMCS, Lublin, 81-90.

Čebotareva N. S. 1987, Stellung und Alter der Moskau — Inlandeisdecke. Petermanns Geogr. Mitt., 131, 1, 1-9.

Dąbrowski S., Dzierżek J., Krupiński M., Lindner L., Marciniak B. 1987, On the occurrence of two series of interglacial sediments in the Piła section (Northern Poland). Bull. Polish Acad. Scis., Earth Scis., 35, 4, 379-390.

Harasimiuk M. 1980, Rzeźba strukturalna Wyżyny Lubelskiej i Roztocza (only in Polish: Structural relief of the Lublin Plateau and Roztocze). Rozprawa habil., UMCS, Lublin, 136 p.

Harasimiuk M., Henkiel A. 1977, New kind of karst forms on the chalk area Lublin Upland. Proceedings Intern. Speleol. Congress, Sheffield, 238-240.

Harasimiuk M., Henkiel A. 1980a, Kopalne formy dolinne w okolicy Łęcznej i ich znaczenie dla paleogeografii dorzecza Wieprza (Fossil valley forms in the vicinities of Łęczna and their importance for paleogeography of the Wieprz river drainage system). Kwartalnik Geol., 25, 1, 149-164.

Harasimiuk M., Henkiel A. 1980b, Objaśnienia do Szczegółowej Mapy Geologicznej Polski — arkusz Łęczna (only in Polish: Explanations for Detailed Geologic Map of Poland —sheet Łęczna). Inst. Geol., Warszawa, 72 p. + 7 tabl.

Harasimiuk M., Henkiel A. 1980c, Szczegółowa Mapa Geologiczna Polski 1 : 50 000 — arkusz Łęczna (Detailed Geologic Map of Poland — sheet Łęczna). Inst. Geol., Warszawa.

Harasimiuk M., Maruszczak H., Wojtanowicz J. 1988, Quaternary stratigraphy of the Lublin region, SE Poland. Quater. Stud. in Poland, 8 (1987), 15-25.

Imbrie J. and 8 others 1984, The orbital theory of Pleistocene climate; Support from a revised chronology of the marine $\delta$ [18]O record. Milankowitch and Climate, 1, Ed. A. Berger et al., Dordrecht, 269-305.

Jahn A. 1956, Wyżyna Lubelska — rzeźba i czwartorzęd (Geomorphology and Quaternary history of Lublin Plateau). Prace Geograficzne IG PAN, 7, Warszawa, 453 p.

Janczyk-Kopikowa Z. 1969, Plejstoceńska flora w Podgłębokiem na Lubelszczyźnie (The Pleistocene flora of Podgłębokie in the Lublin Region). Biul. Inst. Geol., 220, Warszawa, 51-72.

Janczyk-Kopikowa Z. 1979, Flora kopalna z Łańcuchowa (Fossil flora from Łańcuchów). Biul. Geol. UW, 23, Warszawa, 119-129.

Janczyk Z., Mojski J. E., Trembaczowski J. 1960, O występowaniu utworów interglacjalnych w okolicy Cycowa (only in Polish: On the occurrence of interglacial deposits in the vicinity of Cyców). Przegląd Geol., 8, 2, 99-99.

Konecka-Betley K., Maruszczak H. 1989, Analiza paleopedologiczna profili gleb leśnych w Polsce SE datowanych na okres interglacjalu lubelskiego. (In print).

Lindner L. 1984, An outline of Pleistocene chronostratigraphy in Poland. Acta Geol. Polon., 34, 1-2, 27-49.

Lindner L. 1987, Main stratigraphic problems in the Pleistocene of Poland. Bull. Polish Acad. Scis., Earth Scis., 35, 4, 343-358.

Lindner L. 1988, Jednostki glacjalne i interglacjalne w plejstocenie Regionu Świętokrzyskiego (Glacial and interglacial units of the Pleistocene in the Holy Cross Mts). Przegląd Geol., 36, 1, 31-39.

Lindner L., Maruszczak H., Wojtanowicz J. 1985, Zasięgi i chronologia starszych nasunięć stadialnych lądolodu środkowopolskiego (Saalian) między górną Wartą i Bugiem (Extent and chronology of early stadial advances of the Mid-Polish (Saalian) ice sheet between the upper Warta and Bug River). Przegląd Geol., 33, 2, 57–64.

Ložek V. 1976, Klimaabhängige Zyklen der Sedimentation und Bodenbildung während des Quartärs im Lichte malakozoologischer Untersuchungen: Ein Beitrag zum Internationalen geologischen Korrelations programm "Quaternary Glaciations of the Northern Hemisphere". Rozprawy Československé Acad. Věd. Řada Mat. Přir. Věd, 86, 8, Praha, 97 p.

Macoun J. 1985, Stratigraphie des Mittelpleistozäns in Mähren in Bezug auf das Quartär Europas. Čas. Slez. Muz. Opava, A, 34, 125–143 and 219–237.

Maruszczak H. 1964, Mapa Geomorfologiczna województwa lubelskiego 1:300 000 (Geomorphological map of the Lublin voivodeship 1:300 000 — manuscript). Rękopis prezentowany na zjeździe Pol. Tow. Geogr., Lublin.

Maruszczak H. 1972, Wyżyny Lubelsko-Wołyńskie (only in Polish: Lublin — Volhynia Upland). Geomorfologia Polski, 1, Ed. M. Klimaszewski, Warszawa, 340–384.

Maruszczak H. 1974, Zagadnienie genezy i wieku przełomu Wieprza pod Łęczną (only in Polish: The problem of origin and age of the Wieprz river water gape near Łęczna). Przewodnik XII Ogólnopolskiego Zjazdu Pol. Tow. Geogr., 2, Lublin, 69–73.

Maruszczak H. 1987a, Loesses in Poland, their stratigraphy and paleogeographical interpretation. Annales UMCS, sec. B, 41 (1986), Lublin, 15–54.

Maruszczak H. 1987b, Stratigraphy of European loesses of Saalian age: was the inter-Saalian a warm interstadial or a cold interglacial? Catena Supplement, 9, "Loess and Environment", Ed. M. Pécsi, 67–80.

Mojski J.E., Rzechowski J. 1969, Plejstocen okolic Podgłębokiego na Polesiu Lubelskim (The Pleistocene from the vicinity of Podgłębokie in the Lublin Polesie). Biul. Inst. Geol., 220, 13–50.

Paszewski A. 1950, Ślady interglacjału w Łańcuchowie nad Wieprzem (Traces of interglacial sediments at Łańcuchów on Wieprz). Annales UMCS, sec. B, 4, Lublin, 271–286.

Przeglądowa Mapa Geomorfologiczna Polski 1:500 000, arkusz Lublin (General Geomorphological Map of Poland 1:500 000 — sheet Lublin). Instytut Geografii i Przestrzennego Zagospodarowania PAN, Warszawa 1980.

Różycki S. Z. 1980, Principles of stratigraphic subdivision of Quaternary of Poland. Quater. Stud. in Poland, 2, 99–106.

Rühle E. 1956, Profil geologiczny osadów interglacjalnych w Olszewicach koło Tomaszowa Mazowieckiego i w Łańcuchowie nad Wieprzem (Geological profiles of the interglacial sediments in Olszewice near Tomaszów Mazowiecki and in Łańcuchów on the Wieprz river). Biul. Inst. Geol., 100, Warszawa, 263–270.

Shelkoplyas V. N. and 9 others 1985, Khronologiya obrazovaniy loessovoy i lednikovoy formatsiy zapadnoy chasti USSR i sopredelnikh teritoriy. Inst. Geol. Nauk, Akad. Nauk Ukr.SSR, Preprint 85-18, Kiev, 52 p.

Skompski S. 1975, Czwartorzędowe osady i procesy geologiczne u północnego podnóża Wyżyny Lubelskiej (Quaternary sediments and geological processes in the northern forefield of the Lublin Upland). Biul. Inst. Geol., 290, Warszawa, 141–166.

Środoń A. 1969, Pozycja stratygraficzna flor kopalnych Lubelszczyzny zaliczanych do interglacjału mazowieckiego (Stratigraphic position of fossil floras in the Lublin Region referable to the Mazovian interglacial). Biul. Inst. Geol., 220, Warszawa, 5–12.

Zoeller L., Wagner G. A. 1987, The method of thermoluminescence dating applied to paleosols. INQUA XII Intern. Congr., Programme with Abstracts, Ottawa, 296–296.

## STRESZCZENIE

Utwory czwartorzędowe i odpowiadające im formy rzeźby w okolicy Łęcznej (ryc. 1) są różnie interpretowane. Część tych, które na Szczegółowej Mapie Geologicznej Polski (arkusz "Łęczna", 1980) wiązane są ze zlodowaceniem ostatnim, według Przeglądowej Mapy Geomorfologicznej Polski (1980) należałoby wiązać ze zlodowaceniem starszym. Dla wyjaśnienia tych wątpliwości podjęto badania geologiczno-morfologiczne, sedymentologiczne, geochronologiczne (datowania TL) i palinologiczne osadów, odsłoniętych w latach osiemdziesiątych w wielkim przekopie miejskiego kanału burzowego. Wyniki przedstawione są na tle zarysu geomorfologicznego (ryc. 2) oraz udokumentowane opisem odsłonięć zestawionych na przekroju geologicznym (ryc. 3).

Szczegółowo badane osady organogeniczne i leśne gleby kopalne występują wśród warstw akumulowanych po ostatniej na tym obszarze fazie akumulacji glacifluwialnej, a przed powstaniem vistuliańskich utworów lessopodobnych. Fakty geologiczne oraz datowania metodą TL świadczą, że osady glacifluwialne reprezentują zlodowacenie Odry (=saalian I). Organogeniczne osady jeziorno-bagienne charakteryzują spektra pyłkowe z sekwencją rozwojową właściwą dla interstadiałów (ryc. 4): w optymalnej fazie rozwoju panowała chłodna odmiana klimatu umiarkowanego. Równocześnie z tymi osadami na wzniesieniach sąsiadujących z jeziorem rozwijały się brunatne gleby leśne. Na profil tych gleb nałożony został później miąższy poziom darniowy, rozwinięty w klimacie przejściowym od borealnego do subarktycznego. Analiza paleogeograficzna osadów organogenicznych oraz tej poligenicznej gleby (pedokompleksu), a także datowania TL pozwoliły skorelować rekonstruowane zdarzenia z kolejnymi etapami 7 stadium $^{18}$O osadów głębokomorskich.

Spektrum pyłkowe osadów bagiennych okazało się bardzo podobne jak we wcześniej zbadanych, pobliskich stanowiskach Łańcuchów i Podgłębokie (Z. Janczyk-Kopikowa 1969, 1979). Okres powstania torfów w tych dwu stanowiskach skorelowano wówczas z interstadiałem Brörup. Fakty obecnie przedstawiane, a także datowania TL wykonane dla osadów z Łańcuchowa (archiwalne próbki H. Maruszczaka), wskazują na potrzebę zrewidowania takiego poglądu. Na podstawie tych faktów przedstawiono próbę rekonstrukcji zmian krajobrazu pojezierza powstałego po regresji lądolodu Odry. Najwięcej uwagi poświęcono zmianom w okresie odpowiadającym 7 stadium $^{18}$O (lublinian = treenian = odintsovian). Gleby, które wówczas powstały, porównano z nieco lepiej rozwiniętym pedokompleksem z 5 stadium $^{18}$O (eemian i najwcześniejszy vistulian).