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CONTRIBUTION TO CHRONOSTRATIGRAPHY AND PALEOGEOGRAPHY OF THE VISTULIAN DEPOSITS IN RIVER VALLEYS OF THE CARPATHIAN FOOTHILLS NEAR PRZEMYŚL

Abstract. Investigations of the deposits building the Pleistocene lower terraces are very useful in the studies of stratigraphy and paleogeography of the older Vistulian in the NW part of the Polish Carpathian Foothills. Vertical sequences of these deposits contain alluvia, eolian (loess) deposits and/or solifluction-debris covers. They are mainly (middle terrace) or entirely (low terrace) of the Vistulian age, and for the most part from the lower part of this period. Mineral-organic horizons and paleosols of interphase and interstadial rank corresponding to the oxygen isotope stages 5 (4–1) and 4, which occur within these deposits, are discussed in this paper. Paleosols of that age were often exposed to denudation processes so they have been rarely found and examined in Polish loess profiles. The results of TL datings allow to determine their chronostratigraphic position.

Key words: Carpathian Foothills, loess, paleosols, solifluction deposits, older Vistulian

INTRODUCTION

Late Quaternary deposits have been studied in river valleys of the border, north-eastern part of the Polish Carpathian Foothills. Special attention was given to the series representing older parts of the Vistulian Glacial i.e. the interval between the Eemian Interglacial and the Vistulian Middle Pleniglacial; it corresponds to the oxygen isotope stages from 5.4 to 4. In the chronostratigraphic scale this interval is situated between 115 ka BP and about 55 ka BP. Deposits of this age constitute a considerable part of the Pleistocene lower terraces, i.e. the middle and low ones, in the investigated area. Vertical sequences of the deposits building these forms contain alluvial series of channel and overbank facies, and series of solifluction-debris and/or eolian (loess) accumulation. Distinct inter- and intra-series paleosols and mineral-organic horizons of interstadial/interphase rank are significant components of these deposits. There are new results of thermoluminescence (TL) datings[1] of deposits from the profiles

[1] TL ages were determined by M. A. Jarosław Kusiak in the TL Laboratory of the Department of Physical Geography and Paleogeography, Maria Curie-Skłodowska University, Lublin.

in Buszkowice and in the Krzeczkowski stream valley presented in this paper. Together with the obtained results of geological, paleobotanical and malacological studies, they throw some light on a complicated paleogeographical development of the area during the older part of the Vistulian. All these results are also important for a chronostratigraphic interpretation of deposits.

THE STUDY AREA

Landscape of the border, north-eastern part of the Carpathian Foothills is represented in Przemyśl environs by a rather uniform and monotonous upland, characterized by not vast planation surfaces occurring at two altitudes: 430–440 m a.s.l. and 330–350 m a.s.l. This area is divided into two separate parts by the deep valley of the San river running evenly with a parallel of latitude (Fig. 1). Several large-scale incised meanders occur in this stretch of the San river, so the valley is composed of some structural narrowings and basin-like widenings. Valleys of the larger right tributaries of the San river — the Olszanka river and the Krzeczkowski stream — run also evenly with a parallel of latitude at their long reaches. A system of the Pleistocene terraces with rock socles has been preserved in these valleys, and mainly in the San river valley (Klimaszewski 1948).

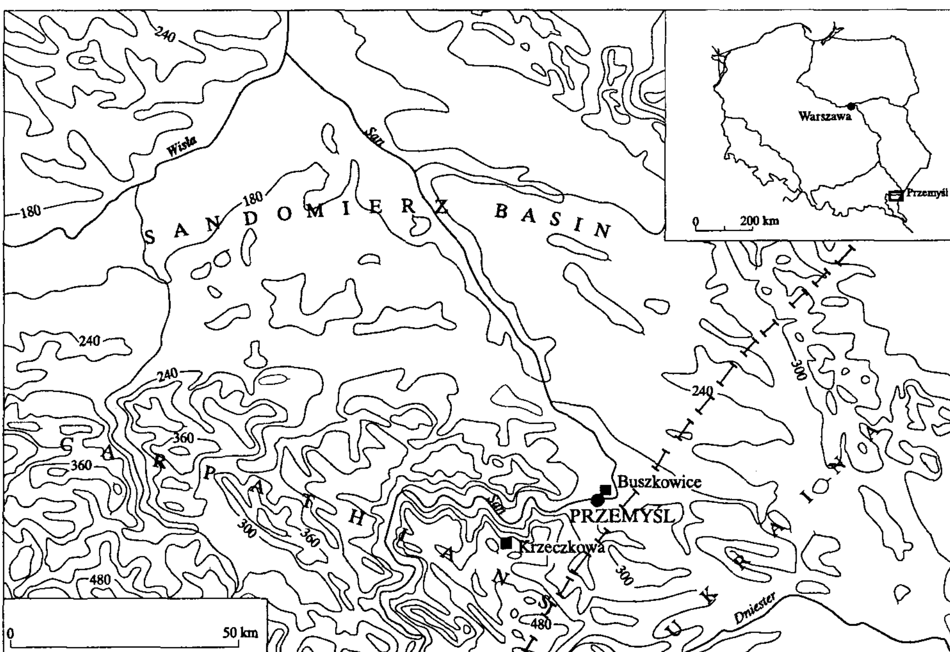

Fig. 1. Situation of the examined area

Accumulation covers of the distinguished here four terraces are attributed to the successive periods of the Pleistocene glaciations. These terraces reach the following relative heights: the so-called "highest" terrace — 65–80 m; high terrace — 40–60 m; middle terrace — 20–35 m; low terrace — 12–17 m. They are largely covered with loess which forms rather continuous and extensive patches in the border part of the Carpathian Foothills, and in the transitional area between this region and the Carpathian Foreland. Loess thickness on the terraces ranges from 5–10 to over 20 m. The covers of the middle and low terraces are mainly built of the internally differentiated Vistulian loess.

LOESS PROFILE NEAR THE BRICK-FIELD IN BUSZKOWICE

The San river leaves the Carpathians in Przemyśl and runs across the Carpathian Foredeep, i.e. the Sandomierz Basin. The middle terrace, reaching the relative height of 20–25 m and separated from the Holocene bottom of the valley by the very distinct bended scarp 14–17 m high, occurs on the left bank of the San river just near the Carpathian margin (Fig. 2). The profile of this terrace was examined in the exposure near the brick-field in Buszkowice and described for the first time by M. Łanczont (1994b). In 1997, owing to advancing exploitation of loam, it was possible to find new facts, i.e. weakly developed paleosols of discontinuous occurrence. They provide evidence of a greater stratigraphic differentiation of the loess deposits from the Early Vistulian and Lower Plenivistulian than it was noticed during the earlier investigation of the exposure. Intraloess paleosols of that age were rarely reported in Polish papers, and they were mainly related to local processes conditioned by relief, slope exposure and slope deluvial phenomena.

Loess cover overlying the bottom series of sandy alluvia on the middle terrace in Buszkowice is very complex, but stratigraphic differentiation of these deposits is univocal though many erosional and sedimentation hiatuses occur within them. This differentiation gives also reason for distinguishing units of second rank, which are presented in Figure 3. These loesses represent two glacial accumulation cycles (Łanczont and Alexandrowicz 1997; Łanczont 1997). The older loess was formed in the Wartanian Glacial, and the younger one — in the Vistulian Glacial. They are separated by a series of fluvial deposits from the decline of the Eemian Interglacial.

Sedimentation of silt deposits during the older stage of eolian accumulation began on the bottom of the San river valley, probably after a short stage of development of periglacial processes which resulted in weathering of the top part of fluvial sands. Loess accumulation started probably in the Lower Pleniwartanian. The Wartanian loess is about 3 m thick, and represented by carbonate silts and silty loams with a considerable content of humus (0.3–0.4%). Its molluscan fauna contains mainly two taxa, i.e. *Pupilla loessica* and *Pupilla*

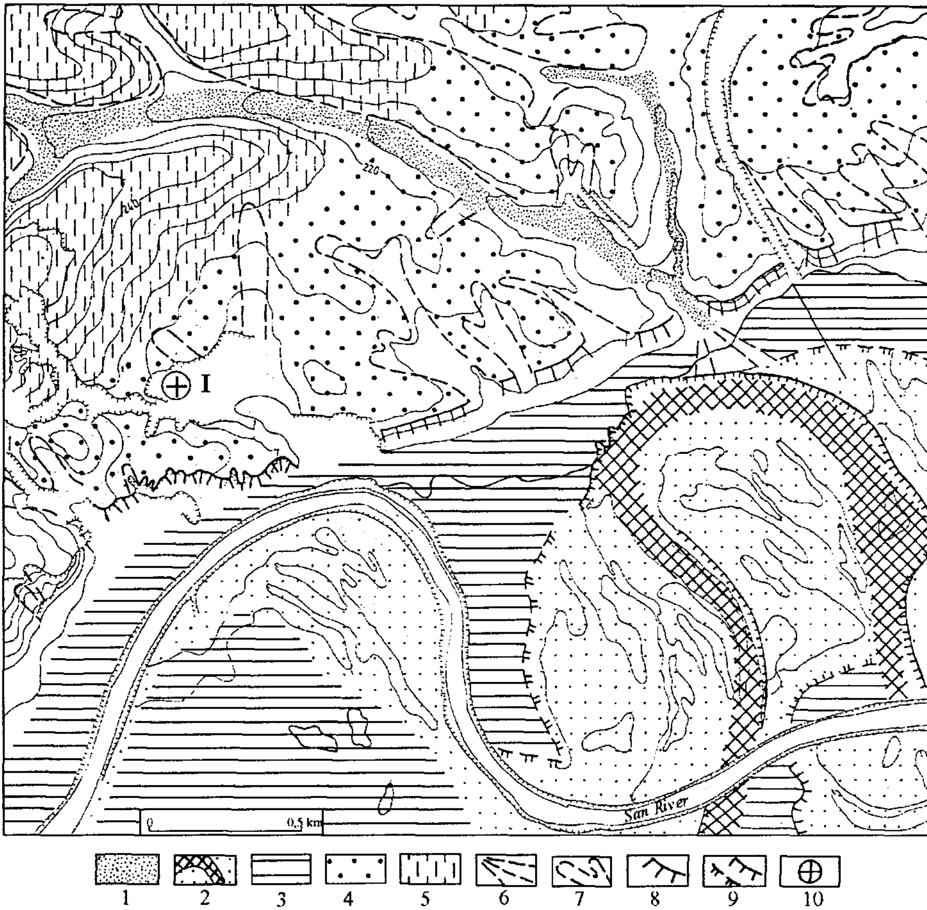

Fig. 2. Geomorphological situation of the Buszkowice profile. 1 — floodplain, 2 — "rendzina" terrace, lower level (6–7 m) with cutoffs and the set of young scroll bars, 3 — "rendzina" terrace, higher level (8–10 m), 4 — Pleistocene loess terrace (middle) 20–25 m high, 5 — slopes and sides covered by loess, 6 — alluvial fans, 7 — denudation valleys, 8 — Pleistocene terrace scarp 10–15 m high, 9 — erosion scarps of the Holocene terraces (distinct and blurred), 10 — profile

muscorum. A small admixture of calcareous remains of *Vallonia tenuilabris*, *Vertigo parcedentata* and *Limacidae* was also found. In the light of these facts it can be concluded that the Wartanian loess was accumulated in an open environment, where soil of low moisture was covered with grasses and perennial plants, but swampy depressions occurred in places.

The Wartanian loess is divided into the units of lower rank which are termed according to the stratigraphical division of Polish loesses published by H. Maruszczak (1991): early upper older loess (LSg3), middle upper older loess (LSg2), and late upper older loess (LSg1). The LSg3 is layered and disturbed by involutions. It was accumulated on a very wet, aggraded bottom

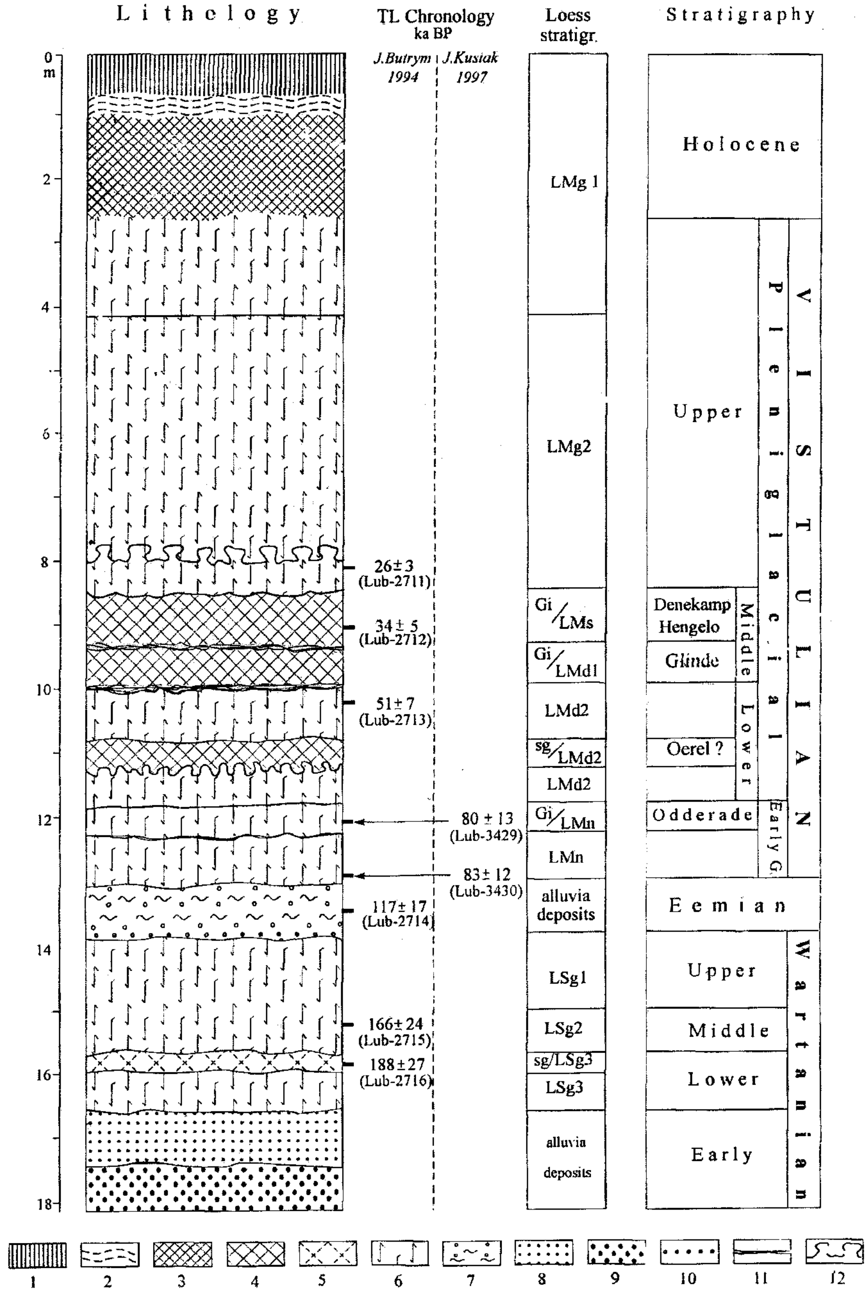

Fig. 3. Lithology and stratigraphy of the loess deposits in the Buszkowice profile. Holocene soil: 1 — humus horizon, 2 — eluvial horizon, 3 — illuvial horizon, 4 — well developed interstadial soil, 5 — poorly developed soil, 6 — loess, 7 — alluvial loam with gravels, 8 — fluvial sands, 9 — fluvial sands with gravels, 10 — channel pavement, 11 — ortstein, 12 — involution structures

of the contemporary valley. Lithological features of the massive LSg2+1 loess indicate very short eolian transport and subaerial sedimentation in rather dry and cold environment of grassy steppe-tundra; such conditions favoured humus accumulation and carbonate preservation. Top layers of the LSg3 are transformed into soil sediment with rather high humus content (up to 0.44%). However, the loess layers representing the Middle Pleniwartanian are less differentiated; gleying symptoms occur in the top of the LSg2 only in places.

Distinct erosional surface over the LSg layers is marked by a typical gravel pavement. That erosion destructed the upper layers of the Wartanian loess, probably those which could be affected by the Eemian pedogenesis; therefore, directly under the erosional surface the carbonate loess occurs. The Wartanian loess is cut and overlain by the alluvial loams with gravels which were TL dated at 117 ka BP. These data evidence a stage of strong erosion and removing of deposits from the valley towards the close of the last interglacial.

The younger, i.e. Vistulian loesses are about 13 m thick and lithofacially differentiated into two main complexes.

The lower complex is about 3.5–4 m thick, and consists of three units of non-carbonate loess with many structures typical of a bog-alluvial loess facies. Horizontal layering and alternating lamination with continuous pairs of dark- and light-yellow laminae are in places disturbed by deformations of plication type, involutions and load structures. These disturbances could be connected with loading processes in the contact zone between deposits of different grain size compositions, periodically strongly saturated with water. Casts of small reticulate structure of segregated ground ice are rather common product of frost processes. This loess was accumulated on the surface of the San river terrace, slightly elevated over the braidplain of periglacial river, and seasonally flooded.

Loess of the lower complex is stratigraphically divided into units of lower rank, i.e. stadial and phase ones. They are identified on the basis of the paleopedological criterion, and TL dated. The first loess bed over the alluvial deposits was TL dated at 83 ± 12 ka BP (Lub–3,430). Therefore, this loess represents probably the Early Vistulian, and corresponds to the LMn unit in the stratigraphic scheme of Polish loesses published by H. Maruszczak (1991). Gley paleosol (TL age: 80 ± 13 ka BP; Lub–3,429) developed in the top part of this loess can be correlated with the Odderade Interstadial, according to the West-European stratigraphic scheme of the Weichselian=Vistulian. The middle loess bed is divided into two parts by a primitive interphase paleosol. The upper part consists of a thin loess layer (TL age: 51 ka BP) topped with a weakly developed gley paleosol. Therefore, this complex loess-paleosol sequence corresponds to the so-called lower younger loess (LMd) unit. It should be stressed that so differentiated sedimentation conditions of the loess correlated with the oxygen isotope substages 5.1 and 5.2 and stage 4 are found only in few Polish profiles (Dolecki and Łanczont 1998).

The highest loess unit of the lower complex in the Buszkowice profile was wholly transformed by an interstadial pedogenesis. The sequence of subarctic soils evidences two periods of intensified pedogenesis in cold climate, with humidity fluctuations. The older pedogenesis period is represented by the strongly gleyed, boggy soil (TL age: 34 ka BP) which was probably formed in shrub tundra; it seems to be indicated by numerous plant macroremains. The younger soil-forming process created the upper paleosol of typological features conditioned by fossil microrelief; this paleosol was developed as gley or brown soil. In the light of the TL ages, and with reference to the other loess profiles in Przemyśl environs (Łanczont 1993, 1995) these two periods of pedogenesis can be correlated with the West-European interpleniglacial interstadials: Hengelo and Denekamp. They correspond to the oxygen isotope substage 3.1.

The upper complex of the Vistulian loesses occurring in the near-surface part of the Buszkowice profile is built of the proper, subaerial, carbonate loess, about 8 m thick, representing the upper younger loess (LMg) unit.

SET OF THE VISTULIAN PROFILES IN THE KRZECZKOWSKI STREAM VALLEY

Elongated ridges and flattened interfluve areas rising about 420 m and 350 m a.s.l. are the main morphological and landscape elements in the Krzeczkowski stream catchment. They enclose deep valley running evenly with a parallel of latitude, with flat bottom of variable width which occurs at 215 m a.s.l. near the valley mouth (Fig. 4). A single Vistulian terrace, i.e. the so-called low terrace, occurring in this valley is morphologically weakly visible because it is covered with various slope and eolian deposits. Its relative height increases down the valley from 6–7 m to 10–12 m.

Geological structure of the low terrace was described on the basis of several exposures investigated in the middle reach of the valley (Fig. 4) — i.e. profiles I and II situated in a valley widening, and profile III — in a valley narrowing (Alexandrowicz and Łanczont 1995, 1997).

The early glacial deposits of channel facies and muds of overbank facies rich with humus occur in the profiles I and II (Fig. 5). These muds are related to the Brörup Interstadial on the basis of typical molluscan fauna found in them. The series of humus clays inserted in the dissected mud layer is considered to be the soil deluvia connected with intensive soil erosion and slope denudation during the last phase of the Brörup Interstadial. Pollen spectra of this deposit[2] evidence a steppe-tundra community which was dominant in the contemporary landscape of the Carpathian Foothills,

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[2] Pollen analysis of the sample was made by dr I. A. Pidek from the Department of Physical Geography and Paleogeography, Maria Curie-Skłodowska University in Lublin.

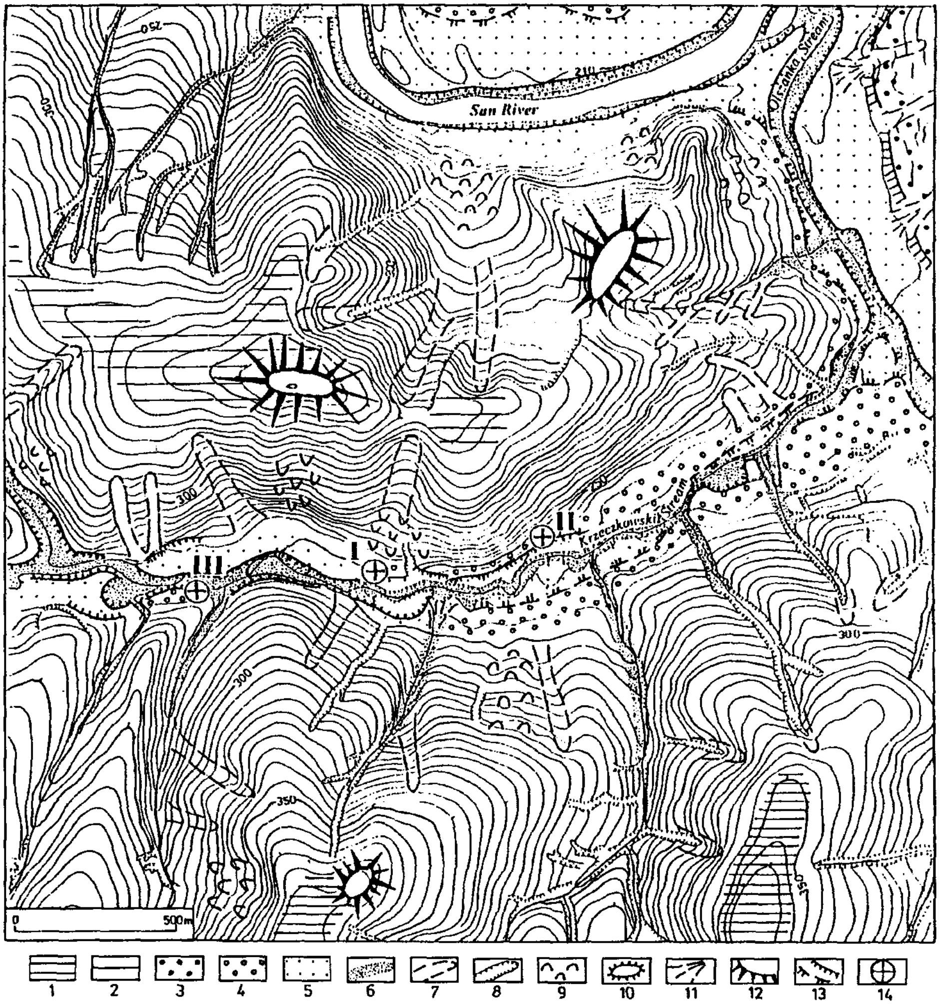

Fig. 4. Geomorphological situation in the Krzeczkowski stream valley. 1 — foothill level (middle or upper Pliocene), 2 — riverside level (lower Quaternary), 3 — Pleistocene middle terrace 20–30 m high (Middle Polish Glaciations), 5 — Pleistocene low terrace 8–15 m high (Vistulian), 6 — "rendzina" terrace (older Holocene), 6 — floodplains, 7 — denudation valleys, 8 — V-shaped valleys, 9 — landslides and slide-creep forms, 10 — denudation remnants, 11 — alluvial fans, 12–13 — erosion scarps of terraces: 12 — high, 13 — low (distinct and blurred), 14 — sites

and a probable occurrence of park forests of taiga type. These early glacial deposits are overlain by solifluction-debris covers and loesses from the Lower and Middle Plenivistulian.

The layer sequence found in the profile III is different. A series of channel deposits is covered by a thick layer of clayey loam on which a single horizon of strongly gleyed boggy soil occurs; it contains 0.9–1.7% of humus. Habitat in

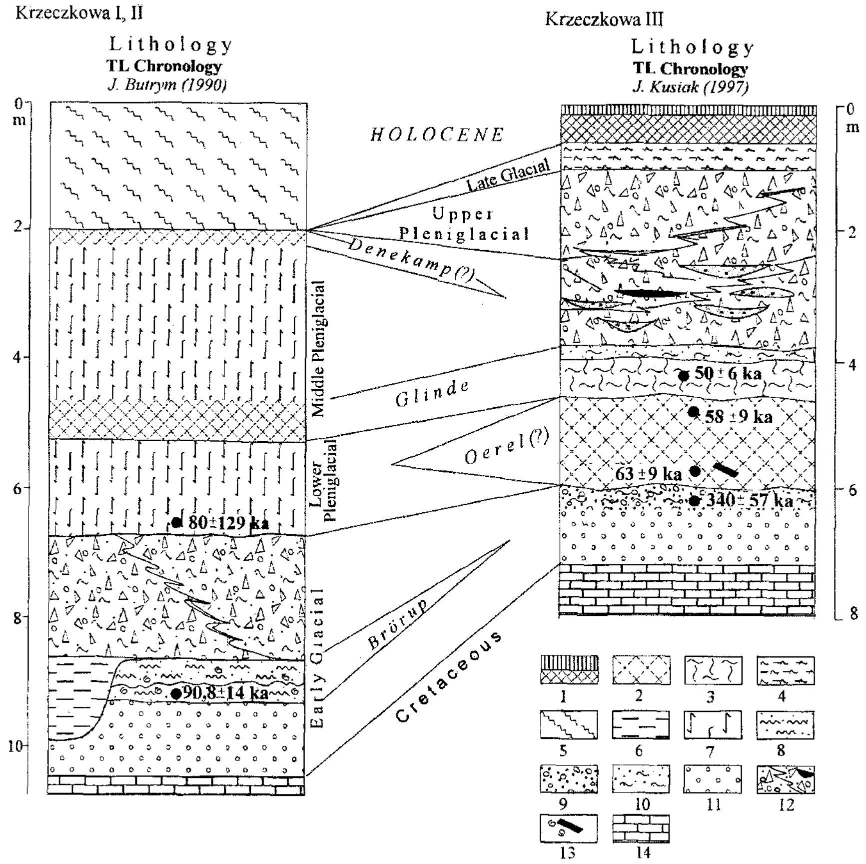

Fig. 5. Lithology and stratigraphy of the Vistulian deposits in the Krzeczkowski stream valley (profiles I, II, III). 1 — Holocene soil of brown earth type, 2 — poorly developed soil, 3 — brown weathered loamy layer, 4 — deluvial loamy deposit, 5 — colluvial clay deposit with debris, 6 — humus clay, 7 — loess, 8 — flood muds and sands, 9 — alluvial loam with gravels, 10 — sandy loam, 11 — fluvial gravels, 12 — gravel-debris and debris covers (with lenticular inserts of sands) of solifluction-fluvial and solifluction origin, 13 — macroremnants (subfossil wood, molluscan fauna), 14 — Cretaceous rock socle

which this soil developed is rather difficult to determine because the analysed sporomorph spectrum is extremely poor (single pollen grains of *Pinus*, *Betula*, *Empetrum*, single spores of *Bryales*, *Lycopodium*, *Botrychium*, one colony of *Pediastrum*), and most of them were redeposited (Alexandrowicz and Łanczont 1995). Soil surface is of erosion-denudation nature; it is overlain by the loam which was strongly weathered in periglacial environment. This loam is covered by thick and complex cover of debris redeposited by solifluction process. Slope material was probably washed by a small tributary of the Krzeczkowski stream. It is indicated by the occurrence of gravels in the lower part of the cover. Loess is absent in this profile.

The profile III was reinvestigated in 1997. Within the humus-boggy horizon a large piece of wood (5 × 10 × 30 cm) was found. It was identified[3] as spruce (*Picea excelsa*) or fir (*Abies alba*) wood on the basis of its anatomical features. Pattern of growth cells suggests that this tree was growing in stable humidity and temperature conditions but climate was very cold and vegetation season short. Mineral substrate of the discussed boggy horizon was TL dated at 63 ± 9 ka BP (Lub–3,426) and 58 ± 9 ka BP (Lub–3,427). It seems to indicate that pedogenesis took place during an interphase warming within the Lower Plenivistulian (?). Therefore, despite cold climatic conditions, a mosaic pattern of habitats (grass-tundra vegetation with clumps of pine, birch and spruce) could occur in the examined catchment which was isolated from the North by the ridges.

The loamy weathering layer overlying the described humus-boggy horizon was TL dated at 50 ± 6 ka BP (Lub–3,428); it probably represents the beginning of the Middle Plenivistulian (perhaps the Oerel or Glinde Interstadial according to the West-European terminology).

The above facts indicate that the low terrace of the Krzeczkowski stream was built up in a different way during the Plenivistulian. It depended on local conditions. Subaerial loesses were accumulated in the lower wide reach of the valley (in the vicinity of the profiles I and II), and solifluction-debris cover — in the upper narrow reach of the valley (in the vicinity of the profile III). This debris cover developed probably till the end of the glacial period, and it was younger than the early glacial debris cover found in the lower reach of the valley.

FINAL REMARKS

In the investigated profiles in Buszkowice and in the Krzeczkowski stream valley there were found the evidences of pedogenesis development during the interphase climatic warmings of the oxygen isotope stage 4. Similar observations were taken in several other profiles of the lower younger loesses (LMd) representing the Lower Plenivistulian in southern Poland (Dolecki and Łanczont 1998; Kusiak and Łanczont 2000). However, different paleoclimatic reconstructions of the Vistulian period in Central Europe give no indications of pedogenesis development at that time (Liedtke and Herbert 1999; Vanderberghe 1992). Thus, these interphase soils within LMd were probably formed in the peripheries of a zone in which they could develop (Bronger and Heinkele 1989). These soils developed in places with more favourable mesoclimatic conditions and with more differentiated vegetation

[3] Analysis was made by prof. J. Bednara from the Department of Anatomy and Cytology of Plants, Maria Curie-Skłodowska University in Lublin.

cover. A mosaic pattern of different ecosystems can be reconstructed: patches of subarctic tundra, forest-tundra and tundra-forest-steppe. Similar situation occurred in the Carpathian Foothills during the cold Upper Plenivistulian (stage 2), as it was described by L. Starkel (1988).

Loesses in Przemyśl environs are situated in the north-eastern peripheries of the occurrence zone of eolian deposits in Poland. A special nature of loess sedimentation in this area was conditioned by the local climatic conditions which favoured solifluction-debris processes during the initial phases of the Vistulian stadials. Therefore, the loess sequences are interlayered in places with the solifluction-debris deposits which could be formed on the sides of smaller valleys (Łanczont 1994a). The Carpathian Foothills in Przemyśl environs can be regarded as a transition zone of periglacial sedimentation — between the South Polish Upland where mainly loesses were accumulated and the mountain areas where solifluction-debris processes predominated.

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STRESZCZENIE

M. Łanczont

PRZYCZYNEK DO CHRONOSTRATYGRAFII I PALEOGEOGRAFII OSADÓW VISTULIAŃSKICH W DOLINACH POGÓRZA KARPACKIEGO KOŁO PRZEMYŚLA

W dolinach rzecznych północno-wschodniej, brzeżnej części fliszowych Karpat Polskich prowadzone są badania młodoczwartorzędowych osadów. Pionowe sekwencje osadów budujących niższe terasy plejstoceńskie zawierają serie aluwialne oraz przejście do akumulacji soliflukcyjnej, gruzowej i/lub akumulacji eolicznej, lessowej. Szczególną uwagę zwrócono na serie osadów terasowych reprezentujące starsze odcinki piętra Wisły. Osady tego wieku mają znaczny udział w budowie teras, tzw. średniej i niskiej. W opracowaniu prezentowane są nie publikowane dotychczas wyniki datowania metodą TL osadów budujących terasę średnią w profilu odsłaniającym się przy cegielni Buszkowice (stanowisko to położone jest przy wylocie doliny Sanu na przedpole karpackie) oraz osadów budujących terasę niską w dolinie potoku Krzeczkowskiego na Pogórzu Przemyskim (ryc. 1, 2, 4).

Ważnym elementem pokryw terasowych jest indywidualizowanie się wyraźnych gleb kopalnych i poziomów mineralno-organicznych rangi interstadialnej oraz interfazowej (ryc. 3, 5). Gleby tego wieku są dość rzadko rejestrowane w polskich profilach, m.in. ze względu na późniejsze procesy denudacji. Wyniki datowania metodą TL pozwoliły na ustalenie ich pozycji chronostratygraficznej.