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LATE PLEISTOCENE LOESS-PALEOSOL AND VEGETATION SUCCESSIONS AT TARNAWCE (SAN RIVER VALLEY, CARPATHIAN FOOTHILLS, POLAND)

Maryna Komar[1], Maria Łanczont[2]

[1] *National Academy of Sciences of Ukraine, Institute of Geological Sciences, Gonchara str 55b, Kyiv, Ukraine, e-mail: mkomar@operamail.com*

[2] *Department of Physical Geography and Paleogeography, Maria Curie-Skłodowska University, Akademicka str. 19, 20-033 Lublin, Poland, e-mail: lanczont@biotop.umcs.lublin.pl*

Abstract

The Tarnawce 1 profile, which occurs in the marginal eastern part of the Polish Western Carpathians, contains loesses representing three last glacial cycles. In this paper we report the results of pollen analysis of the Eemian–Early Glacial pedocomplex and of the Lower pleni-Vistulian loesses with an interstadial paleosol. The pollen spectra of 22 samples were determined. The pollen diagram was divided into 7 local pollen assemblage zones (L PAZ). Interglacial climatic optimum was recorded with the Eemian type of vegetation in the T-4 zone. The coldest conditions occurred during the accumulation of loess, which separates the interglacial and interstadial soils.

Key words: Late Pleistocene, paleosol, loess, pollen, Carpathian Foothills

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INTRODUCTION

Pollen analysis of the deposits of loess-paleosol formation is very helpful in paleogeographical reconstruction of natural environment. It is especially important because loess deposits rarely contain paleontological remains, which could elucidate the conditions of their formation. Furthermore, such an analysis allows us to obtain the equally detailed data about natural environment in whole glacial-interglacial cycle (Bolyhovskaya 1995).

Pollen spectra obtained from loess-paleosol deposits contain the following elements: local (pollen of entomophilous herbs and most of spores), sublocal (pollen of all anemophylous herbs and spores of ferns mainly), quasi-regional (pollen of entomophilous trees and shrubs, and also anemophylous shrubs and some trees – oak, hornbeam, beech), and regional (pollen of pine, spruce, alder and birch) (Gričuk 1989). Therefore, pollen diagrams reflect the changes of vegetation cover in the nearer or farther neighbourhood of an examined site, and also other environmental features such as climate, relief elements and water conditions.

Palynological studies of the deposits of loess-paleosol formation have been intensively developed in Russia and Ukraine since the 40's of last century. It is evidently connected with the occurrence of widespread loess cover on the East European Platform. Many papers concern methodics of pollen analysis of loess deposits (Gričuk 1940, Tyuremnov, Berezina 1965, Paškevič, Bezus'ko 1968, Berezina 1969, Musina, Sahibgireev 1982, Savina 1983, Bolyhovskaya 1991, Komar 1997 and others), and research work in this field is still continued.

Pollen analysis of mineral paleosols has been rather rarely carried out in Poland. Palynological studies concern mainly the Holocene soils of dunes, and the results serve the reconstruction of local vegetational history. Few papers represent the botanical interpretation of pollen identified in the deposits buried under prehistorical archaeological objects, like a burial mound and a Neolithic tomb (Nalepka 1999). Till now, the palynological study of intraloess paleosols and loesses has not been developed in Poland. Sporomorphs occurring in boggy paleosols were determined only in few loess profiles of SE Poland, and the results were the basis of the very broad characterisation of the plant environment in which these deposits had formed (Dolecki 1995, Łanczont 1993, 1995, Maruszczak 1980, Nalepka 1999).

In this paper we report the results of palynological study of the loesses and paleosols from the Tarnawce 1 profile, *i.e.* the Eemian paleosol and the Lower Vistulian loesses with an interstadial paleosol. This work has been made within a greater project, the aim of which is pollen analysis of the Eemian paleosols in Polish loess profiles. The selected loess sites are typical of the greater loess patches within the belt of upland and Carpathian loesses.

LOCATION OF THE TARNAWCE PROFILE

The examined profile is located in the marginal part of the Polish Carpathians, in Przemyśl environs. In respect of orography this part of the Carpathian Foothills is upland with flat interfluve area, and with the remnants of three planation surfaces: intramontane (450–500 m a.s.l.), foothills (380–410 m a.s.l.), and riverside (290–320 m a.s.l.). The wide, meandering valley of the San River is 170 m deep and constitutes the morphological axis of this area. This is transversal valley running evenly with a parallel of latitude, but its short sections are meridional or oblique, conformably to the system of large ingrown meanders (Fig. 1).

The discussed part of the Carpathian Foothills is characterized by the irregular distribution of loesses (Fig. 1). They occur rather as small patches, and mainly in the valleys of the San River and its greater tributaries. Loesses reach the height of 280–320 m a.s.l. only, and their most extensive covers occur on the Pleistocene river terraces.

The Tarnawce 1 profile occurs in the San River valley, within the inner part of a river large meander (Fig. 2). Flysch deposits of the Skole unit form the bedrock. They occur in the system of overthrust folds running meridionally. Variegated and green shales, siliceous marls, and sandstones with shales of the lower Inoceramian beds are the main rock types (Kotlarczyk 1988). Main relief forms within the described meander have the character of structural relief. The riverside planation surface, reaching the relative height of about 100 m, is the oldest relief form, and was dated at the Early Quaternary (Starkel 1984). Strongly asymmetric watershed ridge runs along tectonic stuctures at this altitude (Fig. 2). Several benches and flattenings occur on its more gentle, eastern slope. They correspond to the Pleistocene terraces found in the San River valley (Klimaszewski 1936, 1948, Łanczont 2000, Starkel 1984), *i.e.* the highest (75–80 m), high (40–60 m) and middle (20–35 m) ones. The loess cover of the high terrace (Tarnawce 1 profile) and middle terrace (Tarnawce 2 profile) was described in the papers published by Łanczont (1991, 1993).

The age of the high terrace is related to the period after the retreat of the Sanian 2 ice sheet, which reached the Carpathians' margin and encroached the San River valley at a dozen or so kilometres in its maximum extent. Such an age of this terrace is indirectly evidenced by the lack of tills, by the Scandinavian gravels which sporadically occur as secondary deposit in the terrace alluvial cover (Henkiel, Pękala 1988, Łanczont 1993), and also by the age of the overlaying loess sequence. The eolian cover is about 17 m thick, and contains three main stratigraphic units of loesses and loess-like deposits which represent the last three glacial cycles (Fig. 3).

DESCRIPTION OF DEPOSITS

The Pleistocene deposits at Tarnawce are exposed on the steep right side of a small asymmetric valley which belongs to a valley system draining the eastern slopes of the watershed ridge surrounded with the large meander of the San river. Landslide processes generated by stream lateral erosion mainly shape the valley side.

The top of the exposure reaches 248 m a.s.l. The erosion rock socle of the terrace rises about 35–37 m above the San River channel. It is covered with the thin layer of sands and loamy sands with gravels in which a weak weathering-soil horizon developed. The loess-like loam 3.5 m thick, accumulated in the Odranian Glacial, represents the overlying bottom loess series. Erosion hiatuses are found in its middle and upper layers. The next unit consists of the Wartanian loesses almost 10 m thick. The units of second rank are distinguished on the basis of gley horizons and soil sediments, which occur within these loesses. The Wartanian and Vistulian loesses are separated by the Eemian–Early Glacial pedocomplex. The Vistulian loesses developed in the deluvial facies. They accumulated under rather unstable conditions, simultaneously with the redeposition caused by slope processes; therefore, their thickness is variable and not great (4–5 m). The influence of these processes is also visible in deposit structure. However, these loesses are distinctly and typically differentiated in respect of their stratigraphy (Łanczont 1995), which was determined on the basis of the paleopedological criteria, the succession of strata, and also the correlation with the neighbouring profiles of the Vistulian loesses (Fig. 1). These were the following profiles: Dybawka, Tar- nawce 2, Krasice and Buszkowice (Łanczont 1995). The bottom part of the Vistulian loesses consists of two thin loess beds and two weakly developed brown paleosols, which are related to the beginning and the end of the Interplenivistulian. It should be stressed that these paleosols are characterized by a very great spatial variability, both in respect of their thickness and pedogenesis development. Their upper horizons were destroyed by denudation to different extents as was found in different sections. These facts were recorded during the observation of the exposed wall that was retreating in a result of landslide processes. The detailed field studies of this exposure were being conducted in the period of over 10 years (1989–2000). The top part of the discussed profile is composed of the Upper pleni-Vistulian loesses 2–2.5 m thick, which are carbonate in their upper part, over a weak gley horizon (Fig. 3).

Pollen analysis was made for a fragment of the upper part of the profile, which was examined in one exposure. It contains the Eemian–Early Glacial pedocomplex, the overlying thin loess bed and the interstadial soil (*i.e.* the older of two weakly developed brown paleosols of interstadial rank) developed on it. These layers are characterized in detail below.

The Eemian–Early Glacial pedocomplex occurs at a depth of 6.4–4.2 m. The sequence of genetic horizons is rather typical of the soils of the same age occurring in the Carpathian Foothills (Łanczont 1995). Humus horizon about 0.4 m thick, which resembles turf soil, is loamy and not very rich in humus (0.25–0.28%). The traces of destruction caused by denudation are visible in its upper part, but denudation products overbuild this horizon without any distinct boundary. Transition horizon is about 0.2 m thick, with the traces of weak leaching, not compacted, and impoverished in colloidal clay and iron oxides (about 2%) in comparison with the adjacent horizons. It is structureless and gleyed. Thick (1.55 m), bipartite brown horizon is silty-sandy in its upper part, and sandy-silty in its lower part. It contains higher amount of Fe_2O_3 (to about 4%). Iron compounds occur as spread spots and iron-manganese concretions. This horizon

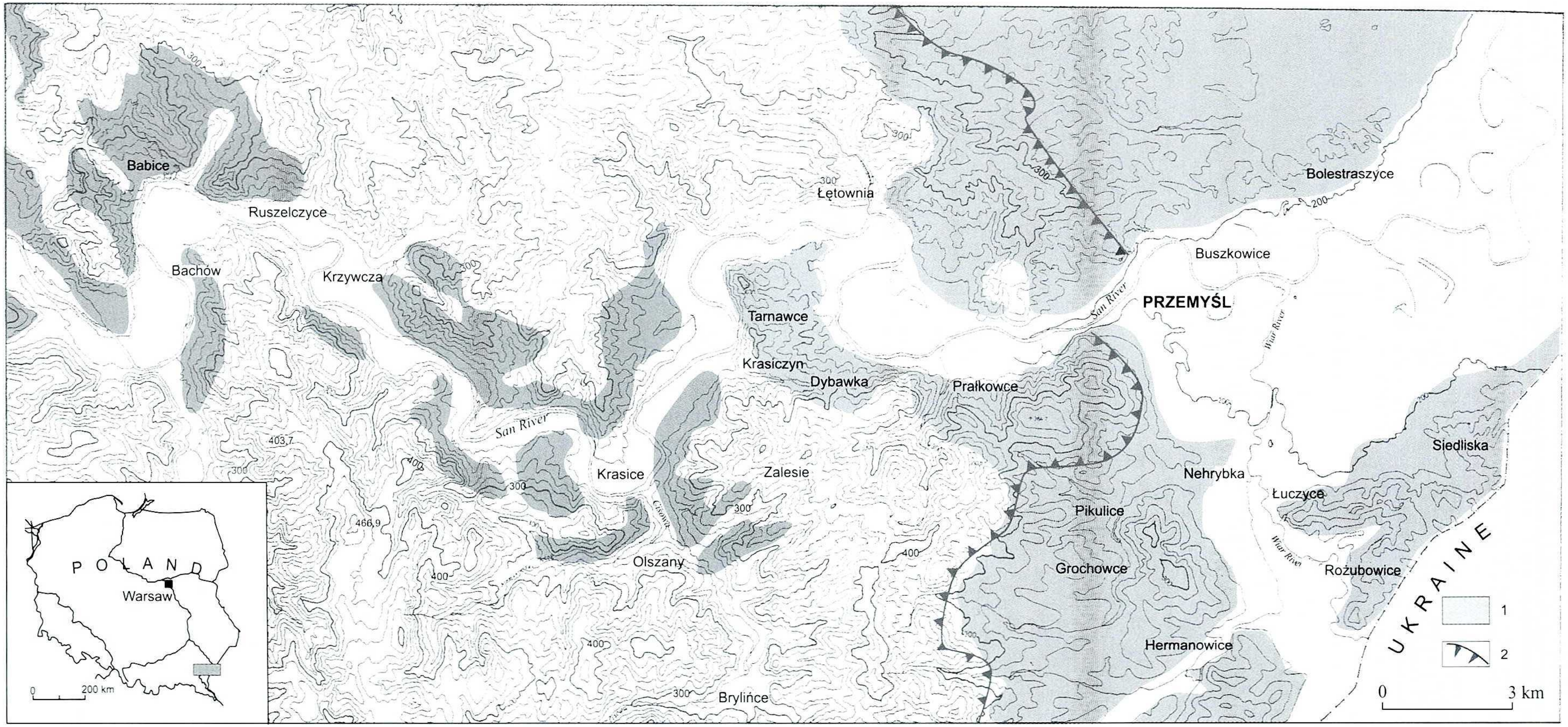

Fig. 1. Distribution of loess in Przemyśl environs (in the foreland of the Carpathians according to the Geological Map of Poland 1:200,000 (Gucik, Wójcik, 1982), and in the Carpathian part of the studied area on the basis of author's own materials). *1* – extent of loesses; *2* – margin of the Carpathians.

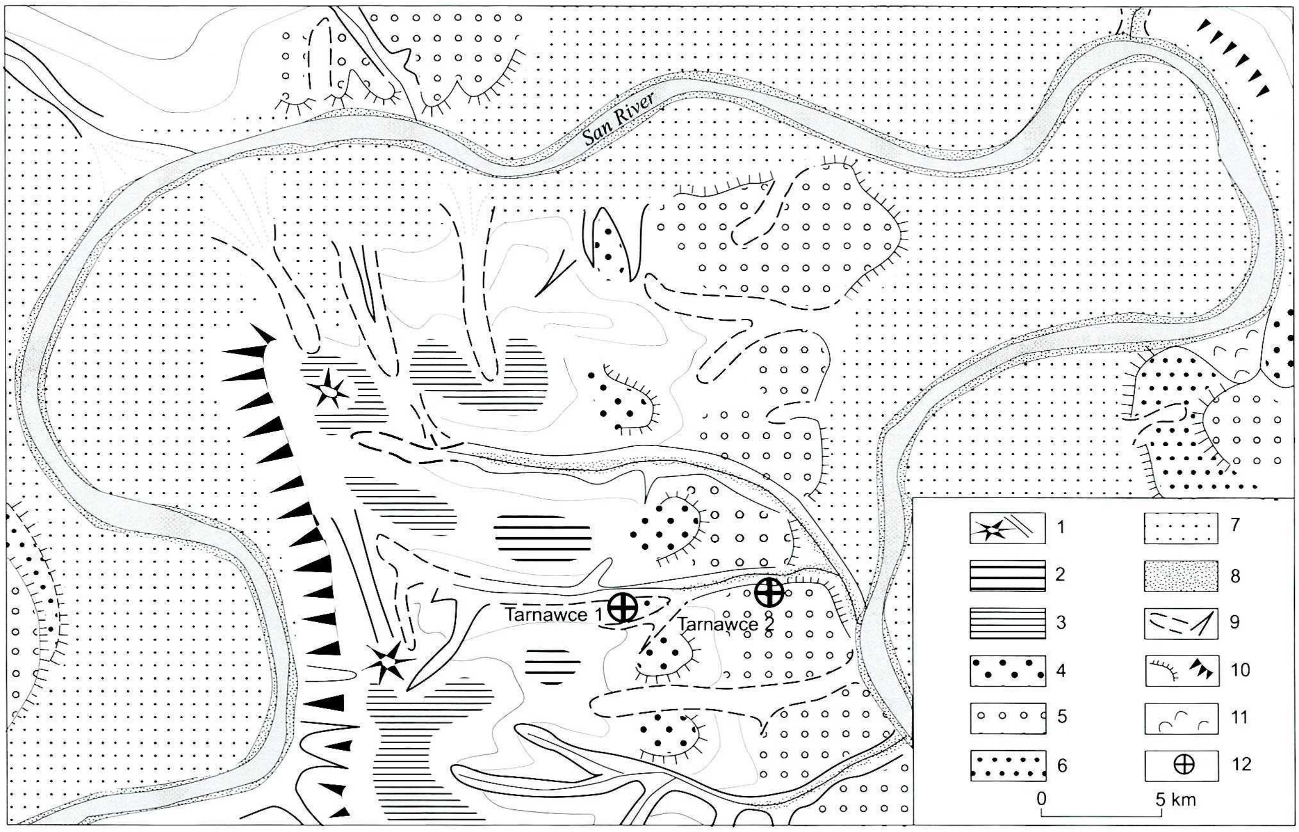

Fig. 2. Geomorphological sketch of Tarnawce environs. *1* – summits and ridges, *2* – river-side level; Pleistocene terraces of relative heights: *3* – 75 m, *4* – 50–55 m, *5* – 20–30 m, *6* – 8–10 m; Holocene terraces: *7* – higher terrace with alluvial fans, *8* – flood terrace; *9* – dellens and erosion dissections, *10* – erosion scarps (high and low), *11* – landslides, *12* – situation of loess sites.

is characterized by well-developed prismatic structure, and it is also gleyed.

The overlying loess bed has very variable thickness, from over 1.50 m to only 0.3–0.4 m, so the description presented here differs from the one published earlier (Łanczont 1991). This is silty-clayey deposit, very compact, with thin ferruginous streaks and small iron-manganese concretions. This loess of slope facies probably represents the Lower pleni-Vistulian.

Weakly developed brown paleosol is the next layer. Its humus horizon is rather thick (0.55 m), loamy, gleyed, of fine platy structure. Humus content reaches 0.3%. Brown horizon is considerably thinner (0.30 m), and its lithogenetic features are only weakly obliterated by pedogenesis. This horizon is loamy, very compact, and strongly gleyed, with the concentrations of iron-manganese concretions; the casts of small recticulate structure of ground ice are visible in this horizon. On the basis of the layer sequence in the examined profile, and in relation to the neighbouring profiles which represent loess cover of the Pleistocene middle terrace of the San River (Tarnawce 2 – see Fig. 2, Krasice – see Fig. 1), this soil is correlated with one of the first interstadials of the Interplenivistulian which corresponds to the Oerel or Glinde interstadial distinguished in Western Europe. In the Krasice profile this soil was TL dated at about 50 ka BP (Łanczont 1993).

The overlying brown interstadial soil (not analysed palynologically), partially denuded, occurs just over the soil described above (Łanczont 1991) or is separated from it by a thin loess layer (Łanczont 1993). It is correlated with the last interstadial of the Interplenivistulian. A soil from that period was found in the neighbouring profile Tarnawce 2, and dated at 28 ka BP by the TL and ^{14}C methods (Łanczont 1993).

METHOD OF POLLEN ANALYSIS

Samples for pollen analysis were taken every 10 cm, and each sample was 5 cm thick. Complex chemical treatment of particular samples was followed by microscopic examination.

Samples 0.1 kg in weight were prepared for pollen analysis in the following way:

1. Boiling with 10% KOH (100°C, 10 minutes)
2. Washing with H_2O (x times, until transparent)
3. Treating with 18% H_3PO_4
4. Washing with H_2O (5–6 times)
5. Flotation with Cd_2J+KJ (specific weight = 2.2 g/cm^3)
6. Treating with 70% HF (2 minutes)
7. Treating with 4% H_3BO_3
8. Acetolysis

The whole prepared material was used for microscopic analysis. The results were subjected to statistical analysis and presented in the form of a pollen diagram (Berglund, Ralska-Jasiewiczowa 1986). The frequency of sporomorphs was different in the particular samples. The sample 13 from a depth of 4.90–4.85 m contained very small number of sporomorphs, so the presence of individual taxa is indicated by the

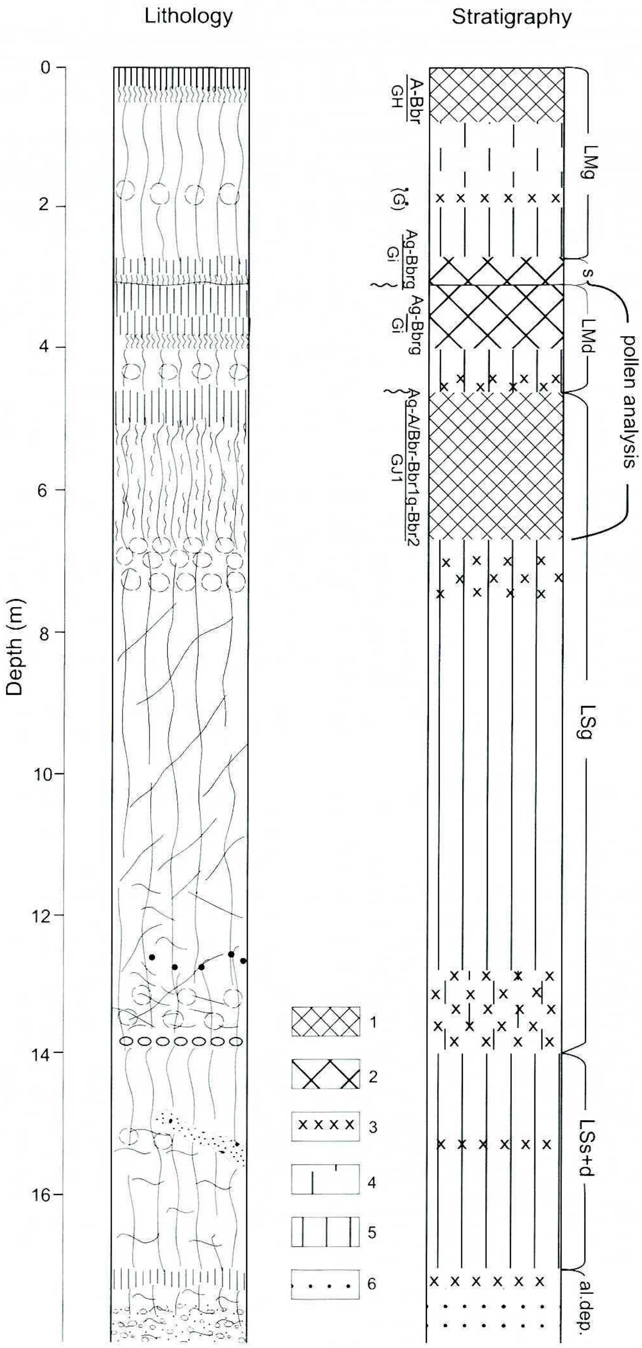

Fig. 3. Tarnawce 1 loess profile. Letter symbols of stratigraphic units of loesses: L – loess, M – younger, S – older, g – upper, s – middle, d – lower, n – lowest. Letter symbols of soil units: G – soils with well developed genetic horizons, H – Holocene soils, I – interglacial soils, i – interstadial soils. Graphic signatures: *1* – Holocene and interglacial soils, *2* – interstadial soils, *3* – soil sediments and poorly developed interstadial soils, *4* – non-weathered, carbonate loess, *5* – weathered, carbonate-free loess, *6* – Pleistocene alluvial deposits.

symbol "+" in the pollen diagram. The sporomorphs are rather well preserved, not numerous of them are corroded or damaged.

The percentages of particular taxa are calculated in relation to the basic sum (AP+NAP), including pollen grains of trees and shrubs (AP), and of dwarf shrubs and terrestrial herbs (NAP). Spores, pollen of aquatic and reed-swamp plants, and *varia* are excluded from the basic sum but their percentages are also calculated in relation to this sum.

DESCRIPTION OF POLLEN ZONES IN THE TARNAWCE PROFILE

Pollen spectra of 22 samples (Fig. 4) were counted. The pollen percentage diagram has been divided into seven local pollen assemblage zones (L PAZ), which are numbered from the bottom upwards, the numbers being preceded with the symbol T (Tarnawce).

Zone T-1 (sample 23; depth – 6.35–6.4 m)

The zone is characterized by the high pollen value of *Betula* sect. Nanae et Fruticosae (34.4%). Other trees and shrubs are represented by the following pollen frequencies: *Betula* sect. Alba (10.5%), *Salix* (7.8%), *Pinus* (6.5%), *Alnus* (4.2%), *Hippophae rhamnoides* (2%), *Corylus avellana* (0.3%). The NAP value is 33%.

The boundary between the T-1 and T-2 zones is marked by the abrupt decrease of the curve of *Betula* sect. Nanae et Fruticosae, and by the rise in the values of *Betula* sect. Alba.

Zone T-2 (samples 22–20; depth – 6.25–5.9 m)

The zone is characterized by the very high pollen frequencies of *Betula* sect. Alba (56.3% – the maximum value in the whole profile). The values of *Pinus* range from 11.6% to 15.0%, and those of *Betula* sect. Nanae et Fruticosae show the considerable decrease. Pollen of *Salix* completely declines. The percentages of *Alnus* fall. Pollen of *Hippophaë* is found only in one bottom sample, and pollen of *Picea* – in one top sample. The curves of *Quercus*, *Ulmus* and *Carpinus* appear and gradually rise, but the values of the last two are low. Grasses and *Artemisia* are less important among herbaceous pollen taxa.

The boundary between the T-2 and T-3 zones is marked by the decrease in the pollen values of *Betula* and the increase in the percentages of *Quercus* and *Ulmus*.

Zone T-3 (samples 19–17; depth – 5.8–5.45 m)

The zone is characterized by the rapid rise of the *Quercus* curve to 15.9–24.6%. The curves of *Ulmus*, *Carpinus*, *Corylus*, *Alnus* and *Picea* are still continuous. Pollen of *Tilia*, *Humulus lupulus* and *Viscum* appear in the upper part of this zone. The values of *Betula* considerably fall from 41.0% to 9.9%. NAP pollen represents plants of different ecological requirements. The amount of Polypodiaceae spores increases.

The upper boundary of the zone T-3 is marked by the decrease in *Quercus* values, and the gradual increase in *Corylus* percentages.

Zone T-4 (samples 16–14; depth – 5.35–5.0 m)

The zone is characterized by the increase of the AP curve, and especially by the considerable rise in the values of thermophilous components. The greatest taxonomic differ-

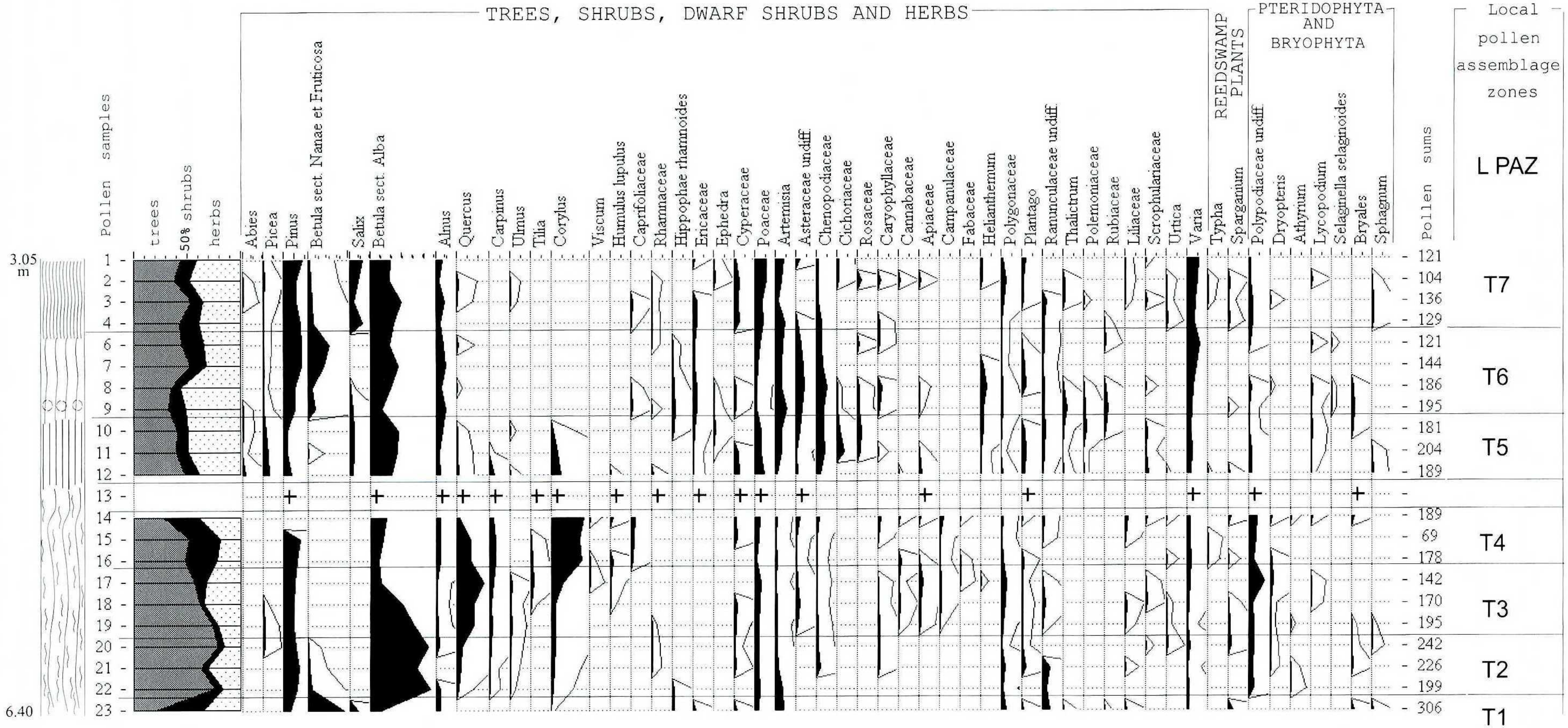

Fig. 4. Percentage pollen diagram from Tarnawce 1 (anal. M. Komar, 2001).

entiation of pollen is noted. The frequencies of *Corylus* are 26.1–29.6%, those of *Quercus* – 3.2–13.5%, of *Carpinus* – 4.2–6.2%, of *Tilia* – 1.4–1.7%. The short curve of *Viscum* appears. Poaceae pollen is more abundant among herbaceous taxa. Pollen of aquatic plants is found.

Zone T-5 (samples 12–10; depth – 4.75–4.35 m)

The values of AP and those of NAP are even equal in this zone. It is characterized by the considerable rise in *Betula* sect. Alba percentages. *Picea* and *Abies* appear. The curves of *Alnus*, *Pinus*, *Quercus*, *Carpinus* and *Corylus* are still continuous. *Ulmus* appears again. Pollen representing plants of open landscape becomes more important in the NAP sum in the upper part of this zone.

Zone T-6 (samples 9–6; depth – 4.25–3.7 m)

The pollen values of thermophilous trees considerably fall. Pollen of plants of lower climatic requirements (*Betula* sect. Nanae et Fruticosae, *Hippophaë rhamnoides*, *Linnea borealis*, and others), and spores of *Selaginella selaginoides*, appear again.

Two pollen subzones are distinguished on the basis of changes in herb composition and in *Betula* species:

T-6a – *Ephedra*, *Artemisia*, Chenopodiaceae, *Helianthemum*, *Betula* sect. Alba

T-6b – *Betula* sect. Nanae et Fruticosae

Zone T-7 (samples 4–1; depth – 3.55–3.05 m)

Pollen of *Betula* sect. Alba is dominant and reaches the maximum of 28.7%. The values of *Betula* sect. Nanae et Fruticosae fall from 5.4% to 2.5%. The curves of *Picea*, *Pinus sylvestris*, *Alnus* are still continuous. Pollen of *Abies* and *Ulmus* appear again. The average frequency of *Salix* is 8.65%. Among the NAP values those of Poaceae and *Artemisia* rise.

VEGETATIONAL HISTORY

The pollen diagram of the Tarnawce 1 profile shows the development of vegetation of interglacial, and partially also glacial and interstadial nature. In this diagram we observe hiatuses due to irregular accumulation, typical of loess-paleosol formation. This is the main feature, which differentiates pollen diagrams of mineral deposits from those of organogenic deposits that usually form continuous sequences.

The pollen diagram of the Tarnawce 1 profile resembles the pollen diagrams made for the Horohiv pedocomplex (correlated with the Eemian and Early Vistulian), which was found in loess profiles of western Ukraine *e.g.* in the Koršiv and Remenov sites (Bezuśko, Boguckyj 1993), and in the Yezupil site (Komar 2002). The discussed diagram resembles also those of the Eemian and Early Vistulian lacustrine deposits in Poland (Mamakowa 1989).

The bottom part of the examined profile represents the last period of the development of open landscape vegetation in subarctic climate (?) (zone T-1). The great amount of dwarf birch pollen, the occurrence of *Sphagnum* spores, sea buckthorn and willow pollen, and the rather high pollen values of herbs may indicate this fact.

A gradual climate warming caused the changes of plant cover, which transformed into birch forests. The proportion of herbs decreased, and their communities were slightly modified. *Betula* sect. Alba reaches its absolute maximum in the zone T-2. The continuous and rising curve of hazel, and next those of oak, elm and hornbeam appear.

The further climate warming resulted in the transformation of birch forests into mixed deciduous forests with the admixture of coniferous trees (*Pinus*, *Picea*). Birch became the retreating component in the forests of the zone T-3. Simultaneously, the amount of trees and shrubs of greater climatic requirements (*Quercus*, *Ulmus*, *Corylus*, *Carpinus*) increased. Thus, the trees of boreal forests were replaced by more thermophilous species. The composition of herbs changed considerably. The proportion and variety of grasses increased. Spore plants became more important.

The earlier initiated vegetation changes resulted in the formation of deciduous forests (*Quercus*, *Alnus*, *Tilia*, *Carpinus*) with rather rich shrub understorey (*Corylus*, *Frangula*, *Sambucus*, *Viburnum*, *Lonicera*). Such components as *Pinus sylvestris* and *Betula* sect. Alba became unimportant. The indicator plants of warm and rather humid climate (*Viscum*, *Humulus*) also occurred in those forests (Niklewski 1968). Polypodiaceae found good development conditions. The vegetation of the zone T-4 represents the climatic optimum in the Tarnawce 1 profile.

A fragment of hornbeam forests' phase is probably recorded in the pollen diagram. It can be supposed that the zone T-5 corresponds to the last part of that phase, when fir and spruce entered into deciduous forests in which hornbeam dominated. Alder was a little more frequent than earlier. The representatives of Ericaceae family and *Ephedra* appeared among dwarf shrubs. The proportion of herbs belonging to Chenopodiaceae, Poaceae, Cyperaceae families, and to *Artemisia* genus considerably increased. Other herbs, the representatives of different ecological groups, were rather abundant.

The discussed above succession of plant communities is typical of an interglacial period. Local pollen assemblage zones T-1–T-5, which were distinguished in the loess-paleosol series of the Tarnawce profile, well correspond to the regional zones distinguished by Mamakowa (1989) in lacustrine deposits from Polish territory.

The gradual climate cooling caused deforestation during the next period. Almost complete decline of deciduous trees provides evidence of a considerable decrease in mean annual temperature. It is also indicated by the return of dwarf birch and sea buckthorn, and by the appearance of *Selaginella selaginoides*. The vegetation of the zone T-6 had the features of a stadial flora, and its development is correlated with the Lower pleni-Vistulian. This long period of unstable climatic conditions was characterised by the occurrence of several slightly warmer interphases separated by cold ones. The warmer interphases are distinctly recorded in several initial soil horizons found in the neighbouring Krasice and Buszkowice sites (Łanczont 2001). However, the sequence of layers in the corresponding part of the Tarnawce 1 profile is not complete due to the development of slope processes. Therefore, the zone T-6 can be probably related only to one or several parts of the Lower pleni-Vistulian. The lower part of this zone is characterised by a considerable proportion of pioneer, xerothermic plants that occupied eroded slopes. Tundra species, which were also characterised by broad tolerance to climatic and habitat conditions, appeared later.

Open birch-pine forests with the contribution of spruce, fir, some deciduous trees (*Quercus*, *Ulmus*) and shrubs (*Lonicera*, *Frangula*) were dominant when the deposits of the zone T-7 accumulated. Willow and alder occupied wet places. This interstadial type of vegetation occurred in the conditions of boreal climate. The nature of this succession is less obvious but on the basis of the obtained data we may confirm the earlier interpretation of the examined profile, *i.e.* that the older/lower brown paleosol is correlated with the first stage of the Interplenivistulian.

It is worth noting that in many profiles of the southwestern part of the Russian Plain, the lower part of the Briansk (Vitačev) paleosol (50–25 ka BP) contains pollen of deciduous trees such as hornbeam, hazel, oak, elm, maple-tree, lime and ash (Gričuk 1972). Therefore, it seems that the occurrence of pollen of some from among the discussed species in the deposits of the lower part of Interplenivistulian at Tarnawce could have resulted not from redeposition but from favourable local conditions of the site situated near probable refuges of temperate arborescent vegetation in the Carpathian Foothills (Bezuśko, Bogucki 1993). It can be also remarked that pollen of the same trees, with oak and elm having continuous curves since the Eemian optimum, was found in the Yezupil profile (situated in the Carpathian Foothills, on the Dniester River), in the layers of the age corresponding to that of the discussed part of the Tarnawce profile (Komar 2002).

FINAL REMARKS

1. The results of pollen analysis indicate that the deposits from the Tarnawce 1 profile accumulated in the Eemian interglacial, and also in the Early Glacial and Lower Pleniglacial of the Vistulian, and confirm the stratigraphic interpretation of this profile, which has been made on the basis of paleopedological criteria.

2. The vegetation succession in Tarnawce is typical of the Eemian. It corresponds to the scheme commonly accepted for this interglacial and resembles the vegetation successions found in the other regions of Poland, Ukraine and Russia. The qualitative and quantitative differences in vegetation composition in the examined profile are of local nature. Sedimentation hiatuses of different rank are responsible for the fact that the hazel and spruce-fir periods are only partly represented in the pollen diagram, and the hornbeam period is not recorded. The lack of poplar pollen is probably caused by its worse preservation in the deposits of loess-paleosol formation.

3. The deposits overlying those with the Eemian vegetation succession represent the Lower Pleniglacial and the Oerel (or Glinde) interstadial. In this case, these deposits correspond to a period of several tens of thousand of years. During the colder stadial, open birch-pine forests with a small admixture of spruce, alder, oak and shrubs occupied the studied area. Adequate section of pollen diagram indicates that the first part of this period was drier.

4. The values of NAP are rather high in the whole diagram. It is a typical feature of the loess-paleosol deposits, also those formed in interglacial periods. These deposits developed on slopes and watershed areas, *i.e.* in different morphological conditions than organogenic deposits formed in low situated floors of valleys and basins.

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