

Palaeoenvironmental Background and Age of the Late Palaeolithic Settlement in SE Poland (A Case Study from the Sandomierz Upland and Carpathians)

Maryna Komar^{*1}, Łanczont Maria², Valde-Nowak Paweł³, Bałaga Krystyna², Hołub Beata², Kusiak Jarosław², Mroczek Przemysław² and Zieliński Paweł²

¹Institute of Geological Sciences, National Academy of Sciences of Ukraine, O. Gonchar str. 55-b, 01054, Kyiv, Ukraine

²Institute of Earth Sciences, Maria Curie-Skłodowska University, Al. Kraśnicka 2 cd, 20-817 Lublin, Poland

³Institute of Archaeology, Jagiellonian University, Gołębia 11, str. 31-007 Cracow, Poland

Abstract: The aim of the natural investigations carried out in two archaeological sites in the SE Poland was to determine their TL age (15 samples) and characterize the vegetation cover with the use of pollen analysis (10 samples) of loess and loess-like deposits sampled in the sites and their close environs. Micromorphological features of loess were examined in one of the sites. The research was carried out in a Late Magdalenian site near Wilczyce village in the eastern part of the Sandomierz Upland, and in a Final Palaeolithic site, with the Świdry Culture materials, near of Mucharz village in the eastern margin of the Small Beskid Mts, flysch Outer Carpathians. Both sites are situated in the Vistula River basin (mountain and upland section), in immediate vicinity of river valleys, i.e. Opatówka and Skawa River, respectively. They are located on high riverbanks, in exposed places that were good observation points. The Magdalenian site was TL dated at about 15 ka BP that corresponds well with the results of radiocarbon dating. The site was surrounded by a mosaic of different vegetation typical of quite cold climate habitats: wet tundra communities, dry steppe with xerophytes, and patches of coniferous trees. The TL dates obtained for the site with the Świdry Culture materials ranged from 10.3 to 11.02 ka BP (Dryas III). Tundra communities with *Selaginella s.* occurred in park-type landscape but the vegetation succession changed after settlement retreat. Coniferous forests with an admixture of birch, next hazel (macroremnants) and alder developed.

Keywords: Poland, archaeological sites, loess, pollen analysis, TL dating, late Palaeolithic.

INTRODUCTION

Gathering information about natural environmental features of the Late Palaeolithic sites is a difficult research problem because of rare occurrence or even lack of organogenic deposits of the same age. We can overcome this problem, among other things, applying pollen analysis to mineral deposits that is rather rarely practised in Poland. Such analysis was our basis for the reconstruction of vegetation cover in two Palaeolithic sites of different ages, associated with covers of silt deposits (loess and loess-like deposits), situated in SE Poland. The samples of mineral deposits taken from these sites were also TL dated.

The research was carried out in a Late Magdalenian site near Wilczyce village in the eastern part of the Sandomierz Upland [1, 2], and in a Final Palaeolithic site, with the Świdry Culture materials, on the periphery of Mucharz village in the eastern margin of the Small Beskid Mts, flysch Outer Carpathians [3]. Both sites are situated in the Vistula River basin (upland and mountain sections), in immediate vicinity of river valleys, i.e. the Opatówka and Skawa rivers,

respectively. The sites are situated about 190 km apart along a straight line SW-NE (Fig. 1).

GEOMORPHOLOGIC SETTING

Vicinity of the Wilczyce Site

The site is located in the eastern part of the Sandomierz Upland, on the Opatówka River. The Sandomierz Upland is a part of the Małopolska Upland, which is the western part of the Central Polish Uplands belt, separated by the Vistula River valley. The area of the Sandomierz Upland is covered by loess deposits (Fig. 1b), up to 30 m thick, accumulated during the Vistulian (Weichselian) glaciation. The upland landscape has typical features of loess relief [4]. Rather flat plateau is strongly dissected by the tributaries of the Opatówka and Koprzywianka rivers, which drain the upland area and flow into the Vistula River. The sub-parallel direction of the Opatówka River valley is conditioned by tectonic structures [5]. Its bottom consists of many basin-shaped widenings and narrow (about 100 m wide) sections. The valley is bordered by loess hills with steep slopes, which are dissected by a dense network of small dry erosion-denudation valleys (Fig. 1d).

Vicinity of the Mucharz Site

The site is located in the eastern margin of the Small Beskid, which is characterized by the relief of medium,

*Address correspondence to this author at the Institute of Geological Sciences, National Academy of Sciences of Ukraine, O. Gonchar str. 55-b, 01054, Kyiv, Ukraine; Tel: +38044 238 19 07; Fax: + 38044 486 93 34, E-mail: makom@ukr.net

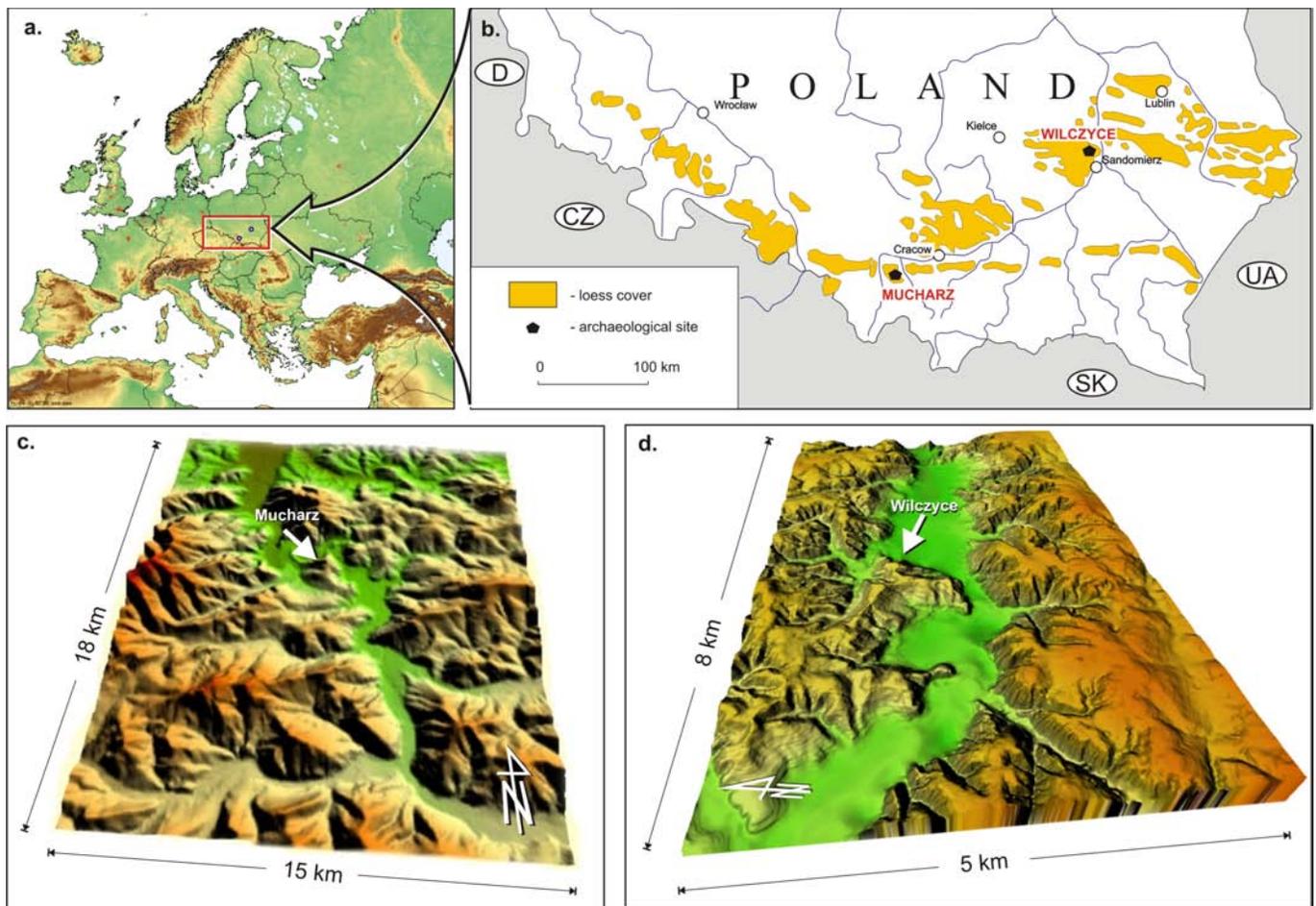


Fig. (1). Location of archaeological sites on the maps of: Europe (a), loess covers in Poland (b) and topographic models.

continuous and dissected mountains separated from the Middle Beskid by the Skawa River valley of gap nature (Fig. 1c). The Small Beskid is mostly composed of thick-bedded, weathering resistant Cretaceous sandstones. The Small Beskid mountain ranges, not exceeding 100 m a.s.l., are separated by narrow and deep valleys. Relative heights reach 600 m. The Middle Beskid consists of many dismembered ranges composed of Magura sandstones interbedded with shales. Ridges are rounded and slopes are not very steep.

The Quaternary deposits are hardly found near the site. However, it should be mentioned that the South Polish ice sheet reached its maximum extent several kilometres of the site, as its lobe entered the Skawa River valley [6, 7]. Its residual deposits (moraine) can be a source of flint erratic material. From among the younger Quaternary deposits, loamy and sandy deposits (generally defined as solifluction and deluvial ones) are more important. Specific loess-like loams of complex origin occur on river terraces. They resemble loess-like deposits of eolian and/or eolian-deluvial origin [8]. Sometimes such deposits are defined as the Carpathian variety of loess [9, 10].

LOCATION AND DESCRIPTION OF SITES, AND ARCHAEOLOGICAL CONTEXT

Wilczyce Site

The open-air site is situated on the top of isolated hill (198 m a.s.l.) forming the northern side of the Opatówka

River valley (Figs. 1d, 2). From the north it is bordered by a large dry erosion-denudation valley, and from the east – by a widening of the Opatówka River valley. Its relative height is about 38 m, and the maximum slope angle reaches 25°. A striking feature of the site surroundings is strong denudation of the Holocene soil cover connected with high relative relief and arable cultivation. Carbonate loess deposits are exposed on ground surface, and modern soils are weakly developed. Loess deluvia fill the bottoms of denudation valleys. Holocene alluvia form a thick (up to 6 m) layer of in the bottom of the Opatówka River valley.

The site belongs to not numerous in Polish territory open camps [11]. The choice of place for camp was certainly not random because from the hill there is a vast view over the almost closed widening of the Opatówka River valley, and this fact was probably important for Magdalenian hunters [12]. The camp of hunters was located in a depression formed in place of a degraded ice wedge – a structure connected with polygonal cryogenic net evidencing the occurrence of permafrost. It was seasonal winter camp, used many times during a long period [2]. The archaeological materials found within the site include abundant faunal remains (horse, woolly rhinoceros, arctic fox, and hare, with some birds such as grouse, herring-gull and lesser black-backed gull). A large number of bone and antler tools were also recovered. Several Lalinde/Gönnersdorf figurines, a



Fig. (2). View of the Wilczyce site from the bottom of the Opatówka River valley.

class Venus figurine, included a range of worked flint objects were recovered here [2].

Mucharz Site

The site is situated in the Skawa River gap through the Beskid Mts. The site lies on the undercut by erosion left bank of the river (Fig. 3), on the territory of the northern periphery of Mucharz village (a rather clearly isolated promontory of the Pleistocene terrace with loess-like cover,

stretched at a height of about 305 m a.s.l. far inside a tight meander of the river). The terrace surface rises over 20 m above the river channel. This terrace can be related to the middle terrace of the Skawa River at Wadowice, which is covered with river sediments, slope (deluvial and solifluction) deposits separated by weathering (initial pedogenesis) and organic horizons, and several metres thick loess. This series, related to the Last Glacial, in total reaches 20 m. The site is open-air and multicomponent, and the oldest settlement traces date back to 10, 000 years ago.



Fig. (3). View of the Mucharz site from the opposite slope of the Skawa River valley.

Extremely rich finds of flint tools and arms date from this settlement phase, and are related to the so-called Świdry Culture. Population of this culture lived in small camps, rather temporary, that resulted from the necessity of moving after herds of reindeers. To date, the traces of this culture have been found mostly in the lowland area, and in the Carpathian Foothills the finds are rare. The Mucharz object is unique, and the only one in the Carpathians so far due to the found traces of “Świderian” shelter [3].

METHODS AND FIELD INVESTIGATION

Field investigations were carried out independently in both sites, in different time and scope. In the Wilczyce site the palaeoenvironmental studies started after the close of archaeological excavations. Such a situation demanded special methods of fieldwork. In the site itself, a small fragment of the excavations was open again, and deposit samples for pollen analysis were taken (marked by W). Three sampling points were situated close each other: W1 – by the border of the ice wedge cast but outside it, W2 – inside the wedge, W3 – by the border but inside the wedge. The sample W7 was taken from surrounding deposits (primary loess) at a distance of 1,5 m from the wedge (Fig. 4). All these samples were TL dated. In order to reconstruct the deposition environment of underlying deposits, i.e. to characterize losses and deforming them cryogenic structures, a pit (over 2 m deep, 50 m long, Fig. 5a, b) was dug in the nearest vicinity of the site. The surface of discontinuity, clearly visible in the pit wall and related to a ground palaeosurface (Fig. 6), evidences a short (interphase-type?) interruption in loess deposition. Two samples (W4 and W5)

for pollen analysis, four samples for TL dating, and four samples for micromorphological analyses were taken from the pit. The sample W4 was taken above the discontinuity line and the sample W5 – below.

During excavations in Mucharz site the investigations were conducted in two objects of the Świdry Culture. Four samples (M1-M4) for pollen analysis and four samples for TL dating were taken from sediment filling and covering a basin-shaped depression, which was recognized as the aboveground dwelling structure in the object 39 (Fig. 7). Additionally, three samples for TL dating were taken from the object 717 [3]. Thermoluminescence dating was made using the total-bleach method, which has the least limitations resulting from the physical features of the dated material [13].

METHOD OF POLLEN ANALYSIS

The palynomorphs from each sample of 100 g dry weight were extracted using modified methods for processing of mineral samples. Hot hydrochloric acid (10%) was used to remove carbonate minerals. 10% $\text{Na}_4\text{P}_2\text{O}_7$ was used to disaggregate the sediment, then sieving with nylon screens to remove the sand fraction. 18% H_3PO_4 was used to remove possible Fe_2O_3 sporomorph's cover. Palynomorphs were separated from mineral material by means of heavy liquid flotation method (specific weight = 2.2 g/cm^3 and 2.0 g/cm^3). Then samples were put in 52% hydrofluoric acid for 24 h to remove silicates. Acetolysis treatment was not used because it makes more difficult to distinguish the redeposited palynomorphs from the contemporary ones. The processed pollen residues are treated with glycerine+water solution and

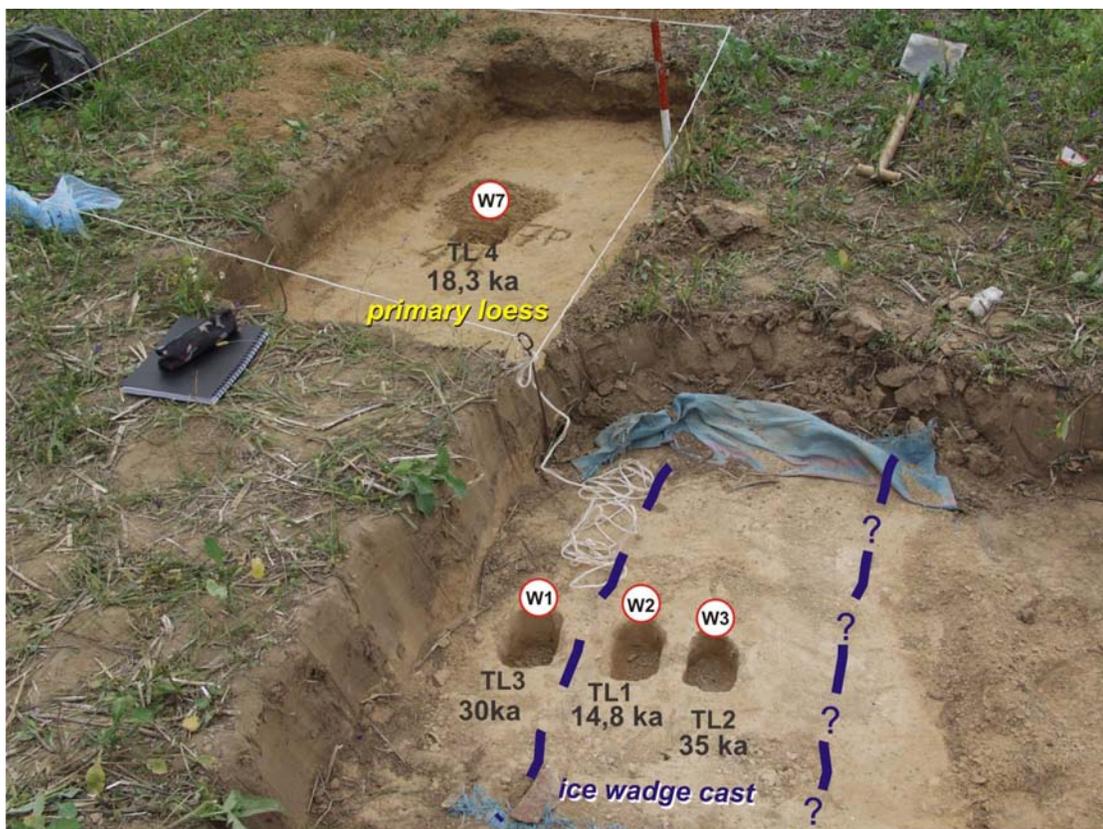


Fig. (4). Wilczyce site - position of TL and palynological samples.

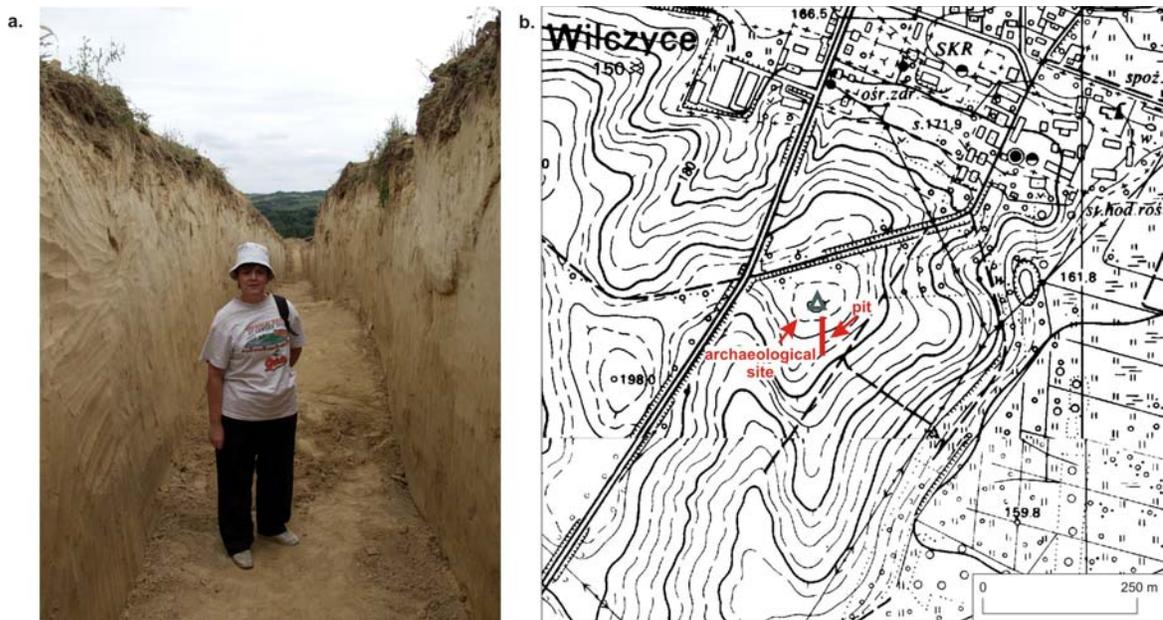


Fig. (5). Pit in loess cover (a; M. Komar as the scale) and its situation relative to the archeological site (b).

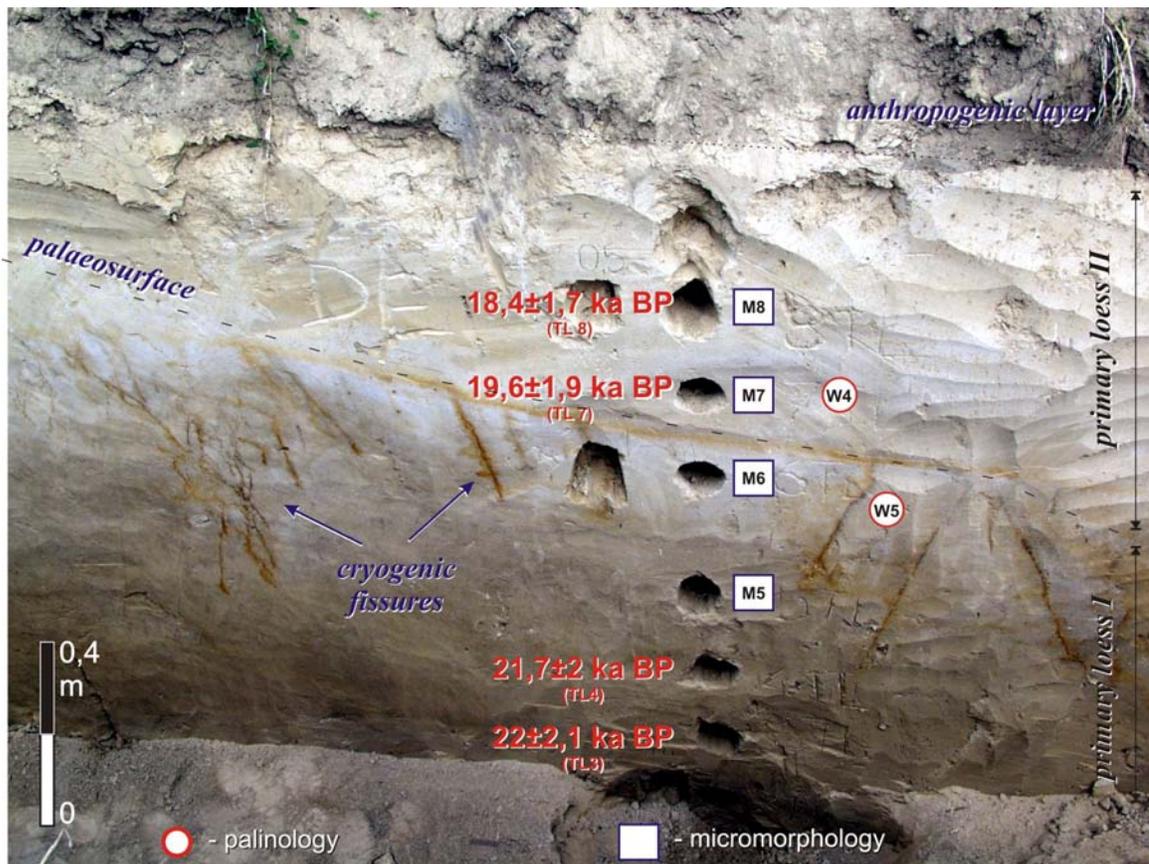


Fig. (6). Wilczyce site – the age and position of samples in the pit.

routinely counted at a magnification of 600, using a Zeiss microscope. Slides were made from the whole processed material, and pollen grains were counted on the whole slide surface. The results were subjected to statistical analysis and presented in the form of pollen histograms and cyclograms with the use of EXEL programme. The frequency of sporomorphs was different in the particular samples. The

percentages of particular taxa were calculated in relation to the total sum (AP+NAP+P), including pollen grains of trees and shrubs (AP), of dwarf shrubs and terrestrial herbs (NAP) and spores (P). Pollen of aquatic plants, *varia* and redeposited palynomorphs were excluded from the total sum but their percentages were also calculated in relation to this sum.

RESULTS OF INVESTIGATIONS

Palynological Analysis of Mineral Deposits

Frequency of palynomorphs in particular samples was different, sometimes rather high. Palynomorphs were rather well preserved; corroded or damaged grains were rare. The total sum for percentage calculations ranged from 169 to 217 grains in the Wilczyce site, and from 144 to 628 in the Mucharz site.

Wilczyce Site

The results of pollen analysis are described according to similarity of taxonomic composition of spectra.

Spectra of the samples W1 and W2 indicate the spread of communities composed of Chenopodiaceae, grasses, and sedges with sea buckthorn (*Hippophaë rhamnoides*). Pollen of *Selaginella selaginoides* and spores of Bryales can confirm the occurrence tundra vegetation patches. Pollen of *Pinus sylvestris* and *P. cembra* can be probably related to the existence of small patches of trees (in favourable habitat conditions) though its long transport was possible (Fig. 8).

The spectra of the samples W3 and W7, slightly different from the rest, are characterized by the occurrence of pine and spruce pollen that was not found in the samples W1, W2, W4, and W5. Similarly as the spectra W1 and W2, they contain rather high pollen values of *Artemisia*,

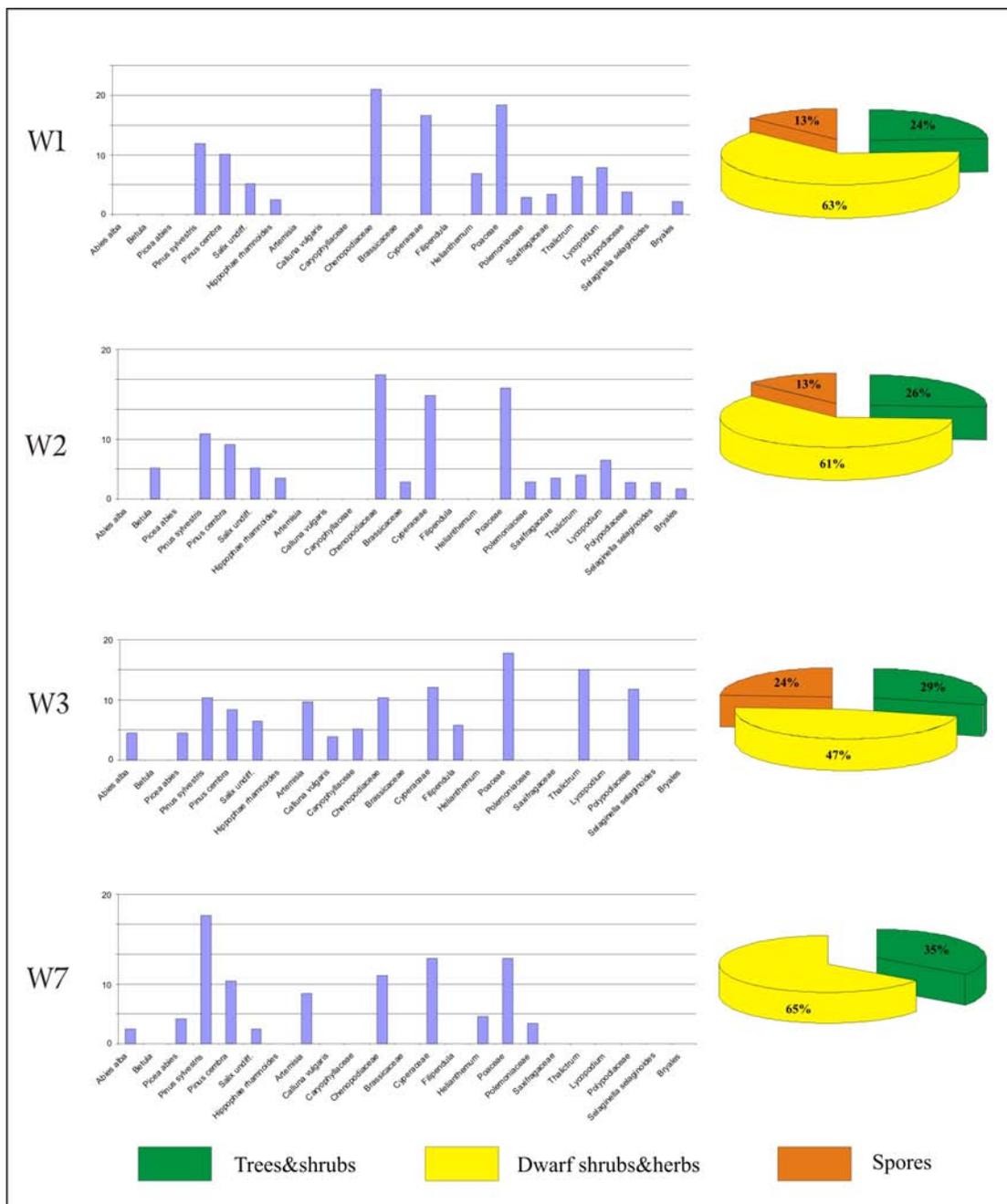


Fig. (8). Histograms and cyclograms showing the pollen percentages in the examined samples in Wilczyce site. The sample location see in Fig. (4).

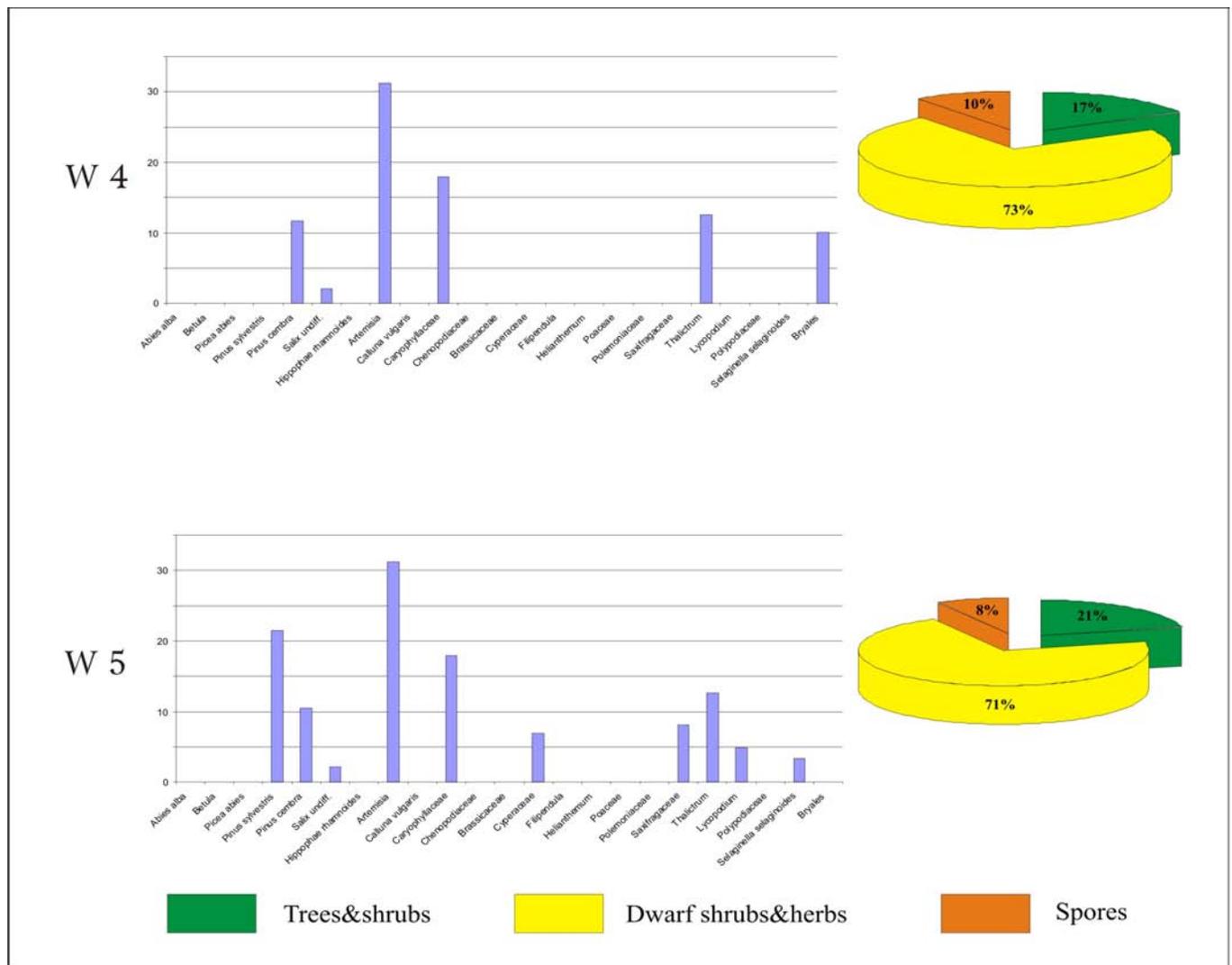


Fig. (9). Histograms and cyclograms showing the pollen percentages in the examined samples from the pit in Wilczyce site. The sample location see Fig. (6).

Chenopodiaceae, Cyperaceae and Poaceae but *Hippophae rhamnoides* and indicators of wet tundra are absent (Fig. 8).

Spectra of the samples W4 and W5 are characterized by rather low AP values, i.e. 17% and 21%, respectively, and very low taxonomic diversity of the recorded pollen flora. Most of the AP grains belong to *Pinus* genus (*Pinus cembra* and *P. sylvestris*). Pollen of *Salix* is considerably less numerous. NAP pollen makes about 70% of total sum, and is dominated by pollen of *Artemisia*, *Thalictrum*, and Caryophyllaceae. These spectra can indicate the period of non-forest communities predomination, i.e. a mosaic of dry steppe with tundra patches (*Selaginella selaginoides*, Saxifragaceae, Bryales), and also, similarly as in the spectra W3 and W7, the probable occurrence of tree patches (*Pinus sylvestris*, *P. cembra*). Their different features, compared with the spectra W1 and W2, are the predominance of herb communities with *Artemisia* (Fig. 9).

Mucharz Site

The samples M2 and M3, characterized by the absence of *Picea* pollen and higher amount of redeposited pollen, can represent a somewhat older period of sediment deposition

(Fig. 10). The samples M1 and M4 were taken from the sediments that were probably deposited later. This conclusion is confirmed by the results of TL dating.

Pollen spectra of samples taken from the fill and its direct cover are characterized by high values of coniferous trees (*Pinus sylvestris*, *P. cembra* and *Picea*), and the occurrence of *Salix*, *Betula* sect. *Alba*, *Alnus incana* among deciduous trees and shrubs (Fig. 10). The percentages of spores (*Lycopodium clavatum*, *L. annotinum*, *Huperzia selago*, *Diphazium tristachyum*, *D. complanatum*, *Selaginella*, *Botrychium boreale*, *Riccia*, Polypodiaceae and Bryales) are rather high. From among herbs, the highest values are reached by pollen of Poaceae and Caryophyllaceae. Pollen grains of Cichoriaceae, Asteraceae, Cyperaceae, Brassicaceae, Apiaceae, Ranunculaceae, Chenopodiaceae and *Polygonum minus* are less numerous.

TL Dating

Wilczyce Site

Loesses underlying the site are little diversified and represent primary, carbonate loess type. Two levels of wedge

Table 1. The Results of TL Dating from the Archaeological Site and Geologic Pit in Wilczyce

Lab. No. Lub-	Sample No.	Description	Depth	Dose Rate DR (Gy/ka)	Equivalent Dose ED (Gy)	TL Age (ka BP)
4475	TL1/o	Wedge border	0.30 m	3.14±0.16	47±4	14.8±1.4
4476	TL2/o	Wedge centre	0.30 m	2.63±0.13	92±7	35±3.3
4477	TL3/o	Outside the wedge	0.30 m	2.99±0.15	89±7	30±2.9
4478	TL4/o	Outside the wedge	0.30 m	3.17±0.16	58±5	18.3±1.7
4486	TL8	Pit	0.65 m	3.16±0.16	58±5	18.4±1.7
4485	TL7	Pit	0.85 m	3.14±0.16	62±5	19.6±1.9
4481	TL3	Pit	2.00 m	3.28±0.16	71±6	21.7±2
4480	TL2	Pit	2.25 m	3.01±0.15	67±5	22±2.1

structures are visible in vertical section. The older one is probably composed of large polygons. The younger structures are preserved only in their bottom part; the upper part was removed by Holocene erosion. The traces of the Magdalenian settlement are probably connected with the younger generation of wedge casts. TL dating indicates that the loess age is between 22 and 18 ka BP (Table 1, Fig. 6).

The remains of the camp were dated by archaeologists at 15 ka BP [1, 2, 12]. This age well corresponds with the TL date (14.8±1.4 ka BP) obtained for a deposit sample taken inside the ice wedge but near its border. Two other samples (from the wedge centre – 35±3.3 ka BP, and from the sediment outside the wedge – 30±2.9 ka BP) were considerably older that can be explained by a distinct hiatus between the archaeological site and surrounding loess. It is possible that in very dynamic permafrost active layer, in which ice wedges were formed, plastic loess was mixed near these structures, and older material was extruded upward. These phenomena could have been responsible both for the overestimation of some TL dating results (TL2/o, TL3/o) and problems with correlation of pollen spectra (Table 1, Fig. 4).

Mucharz Site

Loess-like silty and silty-sandy deposits occurring in the site environs have a high content of the 0.05-0.02 mm fraction that is preferred for TL dating in the Lublin laboratory [13]. Only the sample No2/717 represents the alluvial mixture of sandy, gravely and loamy material, so its deposition time cannot be unambiguously determined (Table 2).

The TL ages obtained for both objects (39 and 717) are within the narrow range (11200-9900 years BP), and form a logical pattern, both vertically and horizontally. They well correspond with geologic-stratigraphic situation of the examined objects, which can be described as irregular concave forms and their fill. TL dates, which came from the fill of two objects (10370±913, 10450±836, 10630±1170, 11020±1200 years BP), indicate the Younger Dryas. Two other TL dates came from sediment covering the object (9900±911 years BP and 10190±876 years BP) [3].

PALAENVIRONMENT CONTEXT

Loess Uplands

The examined loess deposits were accumulated in the Sandomierz Upland during the upper Plenivistulian, i.e. about 18-22 ka BP. In the light of micromorphological analyses, they contain an admixture of older, evidently redeposited loess material as indicated by pedorelictic microfeatures: illuvial papules (fragmented clay coatings formed *in situ* in Bt soil horizon) and also Fe and Mn-Fe nodules (reworked older diffuse nodules) (Table 3) according to Mroczek [14] description. The loess was deposited in the environment of dry steppe with tundra patches. The landscape was open, with a large contribution of *Artemisia* communities. Patches of coniferous trees occurred probably in ecological niches on valley sides [15] though long transport of their pollen was also possible. Climate of the older stage of the described period could have been slightly wetter as indicated by the occurrence of *Selaginella selaginoides*, Saxifragaceae, Bryales, and *Salix*. The younger stage was characterized by *Artemisia*-Chenopodiaceae steppe communities with sedges and grasses (tundra indicators – *Selaginella selaginoides*, Bryales – were absent).

Pollen spectra of samples taken from the archaeological site (fill) and its direct surroundings confirm quite cold climate in the final stage of loess accumulation. They represent open landscape with Chenopodiaceae, grasses, sedges, and also sea buckthorn (*Hippophaë rhamnoides*) but without *Artemisia*. These steppe communities formed a mosaic with vegetation of wet tundra habitats with *Selaginella selaginoides*, Bryales, and Saxifragaceae. Patches of tree vegetation, i.e. *Pinus sylvestris*, *P. cembra* and *Abies alba*, probably also occurred. It is safe to assume that a mosaic of habitats occurred near the site, with patches of park-type forest-tundra with pine. The occurrence of fir pollen in the Vistulian biogenic deposits in the Polish area is usually related to redeposition [15-17]. However, taking into account the good state of preservation of fir pollen grains, we suppose that single trees could have survived in ecological niches that probably occurred on southern slopes

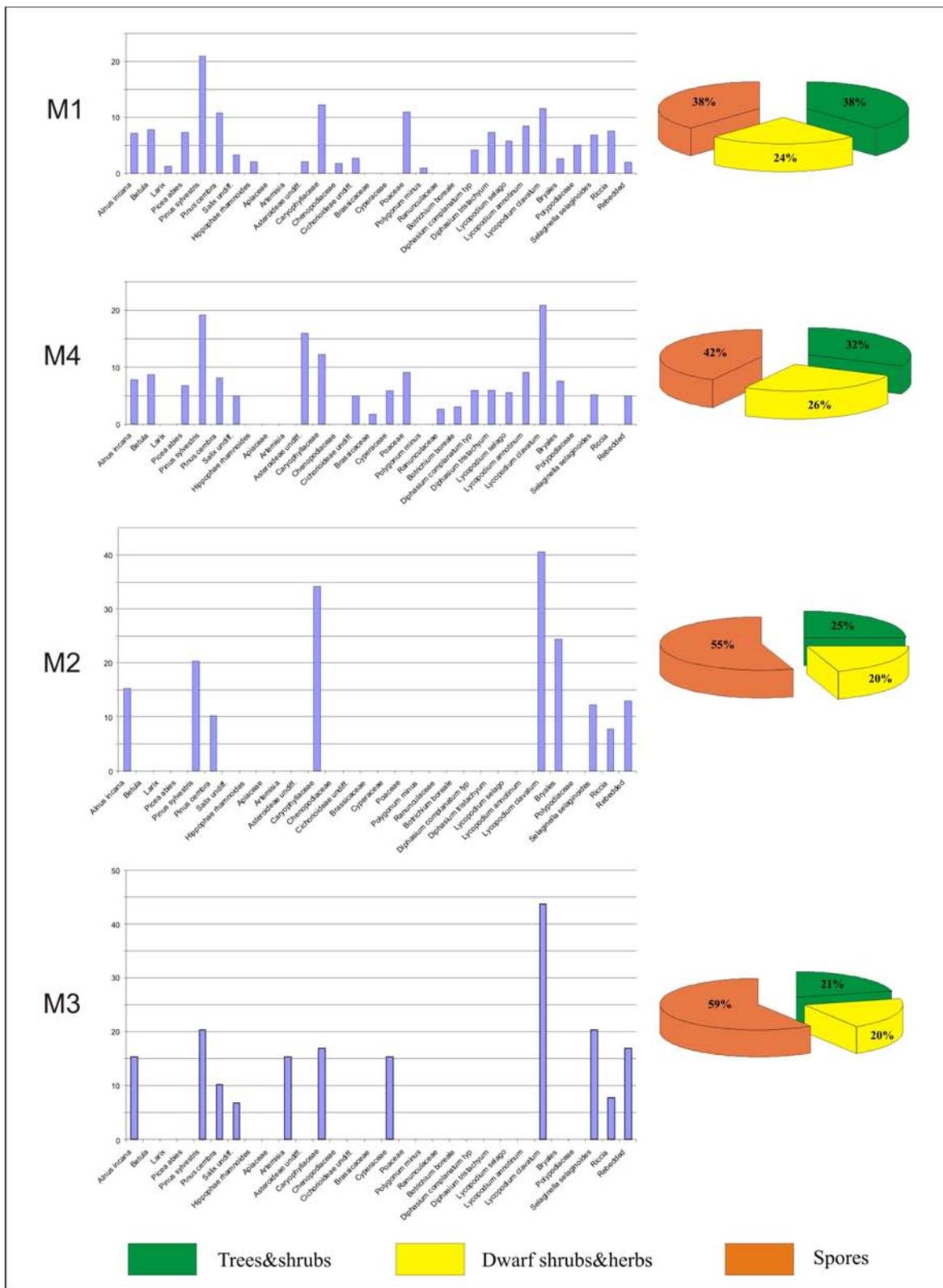


Fig. (10). Histograms and cyclograms showing the pollen percentages in the examined samples directly in Mucharz site. The sample location see Fig. (7).

of the deep latitudinal Opatówka River valley, similarly as in the Kraków environs [18]. This problem needs further studies.

Carpathian Foothills

The high pollen values of coniferous trees and rather high spore frequencies are typical features of the examined spectra. These spectra are the evidence of quite cold climate

Table 2. The Results of TL Dating from the Archaeological Site in Mucharz

Lab. No. Lub-	Sample No.	Dose Rate DR (Gy/ka)	Equivalent Dose ED (Gy)	TL Age(ka BP)
Object 39				
4360	TL1	3.38±0.17	33.5±3	9900 ± 911
4361	TL2	3.09±0.15	32±2.5	10370 ± 913
4362	TL3	3.25±0.17	34±2.5	10450 ± 836
4363	TL4	3.29±0.16	33.5±2.5	10190 ± 876
Object 717				
4378	TL1	3.55±0.30	37.7±3	10630 ± 1170
4379	TL2	3.07±0.27	without result	
4380	TL3	3.59±0.29	39.6±3	11020 ± 1200

Table 3. Selected Micromorphological Features of Loess Sediments from Pit in the Wilczyce Archaeological Site. The Frequency of Features is Recorded in Number of Crosses: One (+) Mark Single, and Four (++++) Common Presence; the Diameters are in Microns

Sample No.	Microstructure	Pedorelicts		
		Papules	Mn-Fe Nodules with Sharp Boundaries	Fe Nodules with Sharp Boundaries
M5	massive, channel	+ (500)	++ (500)	++ (400)
M6	masieve, channel	+ (500)	++ (300)	+ (300)
M7	platy	+++ (600)	++ (700)	++ (800)
M8	platy	+++ (800)	++ (800)	++ (600)

period. The comparison with the published Late Glacial-Holocene pollen diagrams from the areas situated to the north [19, 20] and to the south [21, 22] of the Mucharz site indicates that the composition of analysed spectra resemble rather those from the Carpathian sites due to high pollen values of *Pinus cembra*. In the Carpathian diagram the high percentages of *Pinus cembra* pollen (*Pinus-P. cembra-Artemisia* pollen zones) are related to the Younger Dryas [22]. Therefore, it can be assumed that the examined deposits were also deposited in the Younger Dryas period. In the Carpathian diagrams the occurrence of spruce pollen is recorded since the Late Glacial but its frequencies increase in the Early Holocene, simultaneously with the decrease of *Pinus cembra* pollen values. Assuming that pollen found in the examined deposits represents the vegetation surrounding the studied archaeological site (though long transport of pollen is possible) we can conclude that open coniferous forests, with such plants as *Lycopodium*, *Diphazium*, *Huperzia* and others, occurred near the site. The presence of *Selaginella* spores confirms the occurrence of tundra communities on wet habitats, while dry places were covered by xerophytes with *Artemisia*, Caryophyllaceae, Cichoridaceae, Asteraceaceae, and *Hippophaë rhamnoides*. The occurrence of *Alnus incana* pollen is puzzling. Grey alder forms modern riverine forests growing on river alluvia accumulated mostly in low mountains areas and mountain basins [23]. In the quoted pollen diagrams (Obidowicz 1996) only sporadic occurrence of *Alnus viridis* pollen is recorded, very low curve of *Alnus undiff.* appears only in the Late

Glacial, and the development of alder communities is related to the Boreal period.

After settlement retreat the vegetation succession changed, and coniferous forests were developing, with an admixture of birch and then hazel (macroremnants) and alder.

CONCLUSIONS

Extensive palaeoenvironmental investigations of two different sites of different age at Wilczyce and Mucharz evidence a similar character of seasonal camp locations in quite cold climate at the close of the Plenivistulian and Late Vistulian. These camps were made in park-tundra landscapes with specific relief. The both sites are situated in gap sections of river valleys. Due to such location the sites have several advantages: the occurrence of excellent observation and signal points, and natural traps for migrating herds of game, rich pasturage in bottoms of river valleys and on adjacent slopes, proximity of water.

Interpretation of pollen analysis of loess deposits is very difficult, and sometimes arguable due to the way of their accumulation. However, the results of pollen analysis turned out to be very promising because the spectra obtained from different places reveal some similarities, and allow us to characterize vegetation cover. In the Wilczyce site case, the results of pollen analysis well correspond with the results of palaeozoological studies (Fiedorczuk *et al.* 2007). The remains of horse and woolly rhinoceros together with carnivores point to sufficient food for the local sustenance of

groups of large herbivores [24]. These environmental features, together with specific relief, were the cause of repeated stays of hunters' groups in the same place in winter seasons [12].

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