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Development of vegetation and settlement near Kopki in the Sandomierz Basin during the last 4000 years

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ABSTRACT. The study is based on pollen analysis and radiocarbon datings of the organogenic deposits filling a palaeomeander in the San river valley near Kopki, and on archaeological material. The pollen diagram shows the vegetational changes during the late Holocene from ca. 3800 years ^{14}C BP till recent times. The phases of increasing settlement recorded in the diagram were connected with the younger periods of the Bronze Age, the period of Roman influence and the early Middle Ages up to the present times.

KEY WORDS: pollen analysis, history vegetation, late Holocene, settlement, Sandomierz Basin

INTRODUCTION

Searching for settlement traces recorded in the pollen diagrams from the middle part of the Sandomierz Basin was very difficult because of the small thickness of the organogenic deposits near archaeological sites. The profile of peat deposits in the Kopki environs came up to expectations. Almost a four metres thick profile was collected within the edge zone of the palaeomeander of the San river. It represents only the younger part of the Holocene but the results of the correlation of archaeological, palynological and radiocarbon records turned out to be interesting, also due to the lack of such research in this region (comp. Mamakowa 1962). The preliminary results were presented for the first time in the field seminar (Bałaga et al. 1997).

CHARACTERISTICS OF THE EXAMINED AREA

GEOLOGY AND GEOMORPHOLOGY

The examined site is situated in the middle part of the Sandomierz Basin i.e. in the region called the Lower San Valley (Kondracki 1998) or the San Valley (Wojtanowicz 1990). Archaeological research covered also parts of the adjacent regions – the Tarnobrzeg Plain from the east, the Grębów Plain and the Kolbuszowa Plateau from the west (Fig. 1). The extensive plateaux of the San river catchment are built of the Miocene Krakowiec clays overlain with Quaternary deposits. A distinctive feature of the San river valley is a three-step system of terraces (Wojtanowicz 1978). The highest level is represented by the Pleistocene terrace (10–15 m) built mainly of sands from the Middle Polish Glacial which are overlain with a discontinuous cover of sands and muds from the Last Glaciation on which dunes occur. The Holocene higher terrace cuts in the Pleistocene terrace, built of silty and sandy alluvial soils, is a few metres lower (5–10 m); various systems of meanders have developed on its surface (Szumański 1986). The flood terrace is rather narrow and discontinuous, 2–4 m high, built mainly of channel sands, and sometimes covered with sandy alluvial soils.

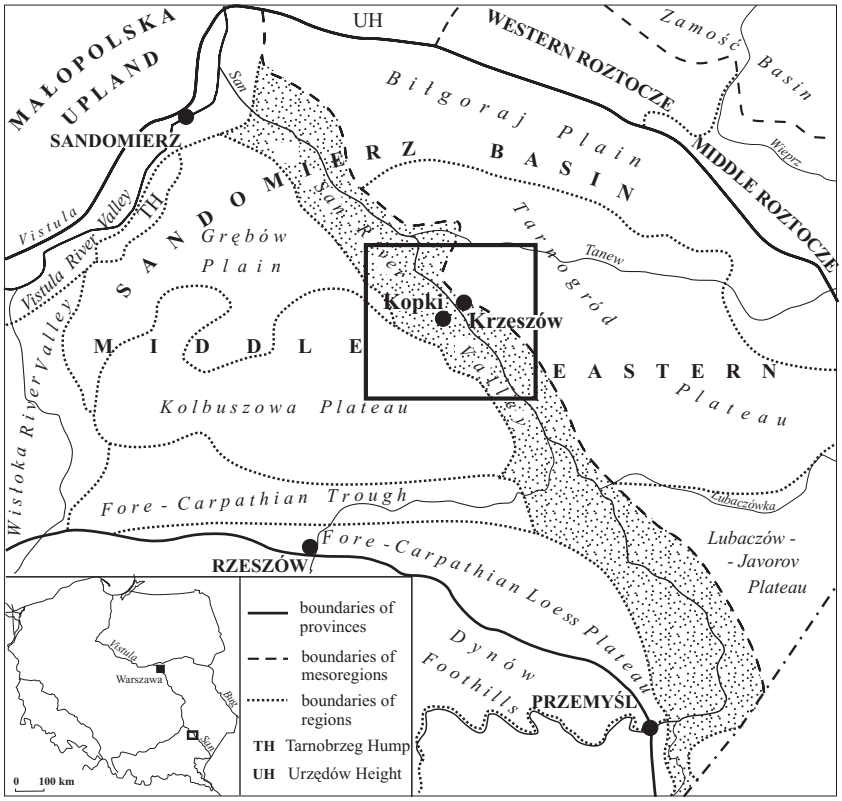

Fig. 1. Location of the examined site with relation to physiogeographical regions of south-eastern Poland

SOILS

In the studied area alluvial soils, mainly medium and heavy ones, predominate. Peaty and peaty-muck soils occupy very small surfaces. Sandy soils of various types (podzolic, brown podzolic and acid brown) prevail on the Holocene higher terrace (Kursa et al. 1988). Dobrzański and Malicki (1950) defined them as sands and clayey sands. Brown soils developed on loamy sands, and pseudopodzolic soils developed on light loamy sands, occur sporadically.

CLIMATE

In climatic regionalization (Gumiński 1948, Romer 1949, Okołowicz 1973–1978) the Sandomierz Basin is divided into two parts: more oceanic west and continental east where the examined site is situated. The mean temperature of January is -3.5°C and of July 18°C, the mean annual precipitation about 670 mm.

RECENT VEGETATION

The distribution of forest communities in the Sandomierz Basin is connected with the terrace relief (Szafer 1972). The remnants of fir-beech or mixed forests can be found on the highest morphological level, i.e. on plateaux. We can found here Fagetum carpaticum, Querco-Carpinetum and Pino-Quercetum forest communities, while Carici elongatae-Alnetum glutinosae occurs in wet depressions and along streams. The Pleistocene terrace is occupied mainly by pine or mixed forests without beech and fir (Vaccinio myrtilli-Pinetum and Pino-Quercetum), and by various types of mires and meadows often overgrowing with osier or alder. Only single poplar trees occur on the frequently flooded Holocene terraces, which are covered with willow thicket and meadow communities.

SETTLEMENT HISTORY

According to archaeological research, the settlement development in Kopki environs was discontinuous and not regular during the prehistorical and early-historical times. The phases of intensified demographic and economic development were interrupted by periods of reduced human activities. The oldest settlement near Kopki was connected with the late Palaeolithic (Magdalenian and Świderska Cultures) and dated at 14–11 ka BP or somewhat

earlier (Schild 1975, Kozłowski & Kozłowski 1977, Kozłowski 1989, Kaczanowski & Kozłowski 1998).

The stabilization of the forest environment at the beginning of the Holocene caused an essential change in the way of life. It turned into a specialised trapper's hunting and fishing. Some groups of the people of the Mesolithic Komornicka Culture coming from the west (Talar 1973) and, next, those of the Janisławicka Culture (Czopek 1996b) occupied the region in a relatively stable way.

The first agricultural population (of the Linnear Pottery Culture) arrived from the south at the close of the 6th millennium BC, and started cultivation of the loess soils in the Rzeszów Foothills (Kadrow 1990). Therefore, the examined area, lying northwards of the loess region, remained probably still being populated by the Late Mesolithic Janisławicka Culture during the next millennium at least. The agricultural population of the Funnel-Beaker Culture settled in this area not before the first part of the fourth millennium BC.

The settlement in the Stone Age and in the Early Bronze Age was not intensive and usually irregular. The intensive settlement development occurred during the period marked by the end of the 13th, which lasted till the beginning of the 4th century BC and was connected with the Tarnobrzeska Group of the Lusatian Culture. It declined during the 4/3rd centuries BC.

The next intensification of the settlement came about in the first centuries AD and was connected with the spread of the Przeworska Culture. A short interruption was caused by the decline of this culture in the 4/5th centuries AD. The progressive increase of human activity took place since the early Middle Ages.

MATERIAL AND METHODS

METHODS

Material for palynological analyses was collected by Instorf (Russian-type) corer. The samples were prepared by standard procedures (Faegri & Iversen 1975, Wasylikowa 1973). Pollen was counted along belts in distance 1 mm, up to about 500 tree pollen grains. The total pollen sum consists of AP+NAP without the taxa of aquatic and swamp plants and spores. The results are presented as a percentage diagram obtained with the use of the POLPAL programme (Walanus & Nalepka 1999). Because of high frequencies of *Alnus*, which is a local species, a simplified diagram was prepared with *Alnus* excluded from the total pollen sum.

The research for the settlement remains from the prehistorical times and the early Middle Ages was made in the environs of Kopki, within a radius of about 10 km from the site in which the peat profile was sampled. The surface examination of this area was thoroughly made within the programme "Archaeological Survey of Poland" (AZP)[1], including also the excavations though on a limited scale.

PROFILE DESCRIPTION

The profile is situated at the altitude of 162 m a.s.l., within a palaeomeander and near the Pleistocene terrace edge about 5 m high.

0.00–1.00 m	Sedge peat, dark brown, moderately decomposed, with *Sphagnum* and wood, nig. 2, strf. 0, elas.+, sicc. 2, lim S.0, Th^{2}3, Tb^{2}1, Tl+
1.00–2.17 m	Wood-sedge peat, dark brown, strongly decomposed, nig. 2, strf. 0, elas.++, sicc. 2, lim S.0, Th^{3}3, Tl^{2}1
2.17–3.12 m	Wood-sedge peat, dark brown, moderately decomposed, nig. 2, strf. 0, elas.+, sicc. 2, lim S.0, Th^{2}3, Tl^{2}1
3.12–3.17 m	Silt, grey, nig. 1.5, strf. 0, elas. 0, sicc. 2, lim 2.0, Ag 4, Th+
3.17–3.33 m	Wood-sedge peat, dark brown, strongly decomposed, nig. 2, strf.++, elas.+, sicc. 2, lim S.0, Th^{3}3, Tl^{2}1
3.33–3.61 m	Sedge peat with silt, grey, strongly decomposed, nig. 1.5, strf. 0, elas. 0, sicc. 2, lim S.0, Th^{3}3, Ag 1
3.61–3.64 m	Sedge peat with silt, dark brown, strongly decomposed, nig. 2, strf. 0, elas. 0, sicc. 2, lim S.0, Th^{3}3, Ag 1
3.64–3.69 m	Sedge peat with silt, rusty, strongly decomposed, nig. 1.5, strf.+, elas. 0, sicc. 2, lim S.0, Th^{3}3, Ag 1
3.69–3.83 m	Silt with sand, grey-brown, nig. 1.5, strf.+, elas. 0, sicc. 2, lim S.0, Ag 3, Ga 1
3.83–5.00 m	Varigrained sand, yellow-rusty-grey, nig. 1.5, strf.+, elas. 0, sicc. 2, lim S.0, Ga 2, Gs 2, Ag+

RADIOCARBON DATINGS

Two samples from the Kopki profile were radiocarbon dated in the Institute of Physics of the Silesian Technical University in Gliwice.

[1] AZP documentation is stored in the Department of Monument Documentation in Warszawa and in the Provincial Department of Monument Protection Service in Przemyśl, Representation in Tarnobrzeg. The studied region is situated within the range of the following AZP sheets (author and year of survey): 94–78 (Florek 1982), 94–79 (Bargieł 1985), 94–80 (Bargieł et al. 1990), 95–78 (Florek 1984), 95–79 (Bargieł et al.1985), 95–80 (Florek 1992), 96–78 (Florek 1990),96–79 (Moskwa 1980), 96–80 (Bargieł et al. 1990), 97–78 (Podgórska-Czopek 1993), 97–79 (Moskwas 1980, and 97–80 (Podgórska-Czopek 1991).

Table 1. Radiocarbon dates of the Kopki profile

No	Depth in cm	Laboratory No	Years 14C		
			BP	BC/AD	
1	84–88	Ki-8274	1105±90	1σ AD 781–791 AD 825–841 AD 859–1021	2 σ AD 691–703 AD 713–751 AD 761–1047 AD 1051–1061 AD 1087–1123 AD 1137–1157
2	123–128	Ki-8275	1440±90	1 σ 471–477 AD 533–685	2 σ AD 423–727 AD 739–773
3	178–182	Ki-8276	1939±110	1 σ 45 BC-AD 220	2 σ 200–190 BC – AD 370–380
4	220–224	Ki-8284	2290±70	1 σ 403–351 BC 317–231 BC 219–207 BC	2 σ 755–719 BC 539–529 BC 521–167 BC
5	275–285	Ki-8452	2530±70	1 σ 790–755 BC 703–539 BC	
6	326–335	Gd 9953	3220±200		

In addition to that, in the Kiev Laboratory, four ^{14}C datings were carried out (calibrated values for these datings were also given) (Table 1). The recent age (0±120 BP) of the sample from the depth of 182–192 cm resulted probably from its contamination with younger material from the upper layers of peat profile. Because of this, this data was not taken into account.

The date from the bottom allowed us to calculate the accumulation rate of deposits. Next, we estimated age limits of pollen horizons and correlated them with archaeological data.

ARCHAEOLOGICAL MATERIAL

About 50 sites are connected with the Early Bronze Age (end of the third and early part of the second millennium BC), and most of them evidence in the examined area the Trzciniecka Culture settlement. Traces of this population occur in the whole discussed area, and greater settlement centres are visible in the San river valley near Łazów, Sarzyna, and Ruda Łańcucka (Fig. 2). The majority of settlements were situated along the San river valley but separately colonized microregions from that period could be found also in smaller valleys.

An intensive development of the prehistoric settlement proceeded in the period starting at the beginning of the 12th century and lasting until 4th century BC and was connected with the Tarnobrzeska Group of the Lusatian Culture. Settlements were established mainly on the high terraces of the San river. More than 130 sites – settlements and cemeteries – are concentrated in several greater centres in the vicinity of the following localities: 1/ Łukowa and Ruda Łańcucka, 2/ Sarzyna, 3/ Łazowa and Bystre, 4/ Krzeszów Górny and Krzeszów Dolny, 5/ Kopki, 6/ Bieliny and Wólka Bielińska, 7/ Rudnik (Fig. 3).

The next settlement phase that was recorded originated from the first centuries AD and was connected with the Przeworska Culture. Traces of this population were found in about 20 sites, mainly in the San river valley near Łukowa, Sarzyna and Kopki.

Medieval settlements were discovered in about 50 sites. Most of them dated from the younger part of the early Middle Ages, i.e. from the beginning period of the Polish State (10–13th centuries). They were sometimes located in the same sites as the settlements of the Przeworska Culture population. Settlement centres of that time were found near Sarzyna, Bieliny and Kopki (Fig. 3).

POLLEN ANALYSIS

The pollen diagram shows vegetation history from about 3800 years BP, when the accumulation of organogenic deposits on sandy substratum started within a palaeomeander in

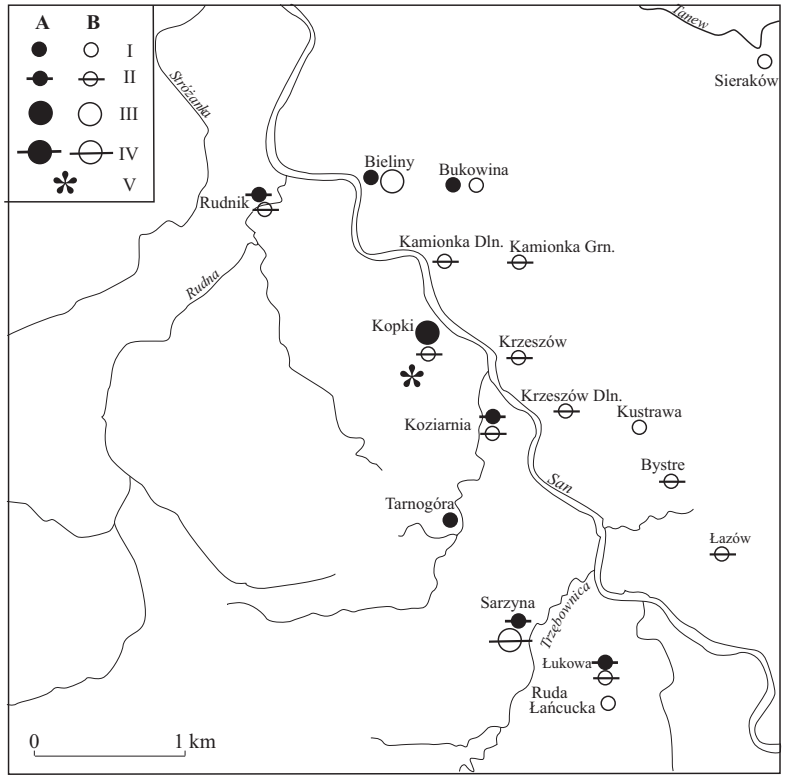

Fig. 2. The prehistorical settlement in the Kopki environs (in general). **A** – the Early and Late Bronze (Mierzanowiceka and Trzciniecka culture); **B** – the sites dated at the period from the Bronze Age to the Laten Age (the Tarnobrzeska group of the Lusatian Culture). The number of the sites in the environs: **I** – 1, **II** – 2 to 4, **III** – 5 to 8, **IV** – 9 to 12, **V** – 13 to 16, **VI** – 17 to 21; **VII** – the site of the collecting of the profile

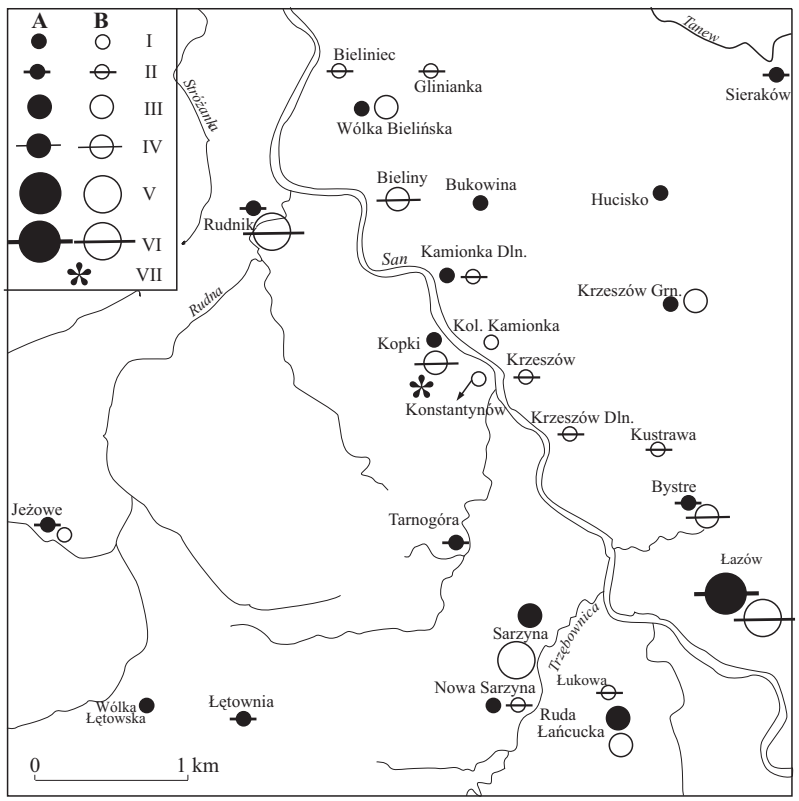

Fig. 3. The settlement prehistorical and medieval in the Kopki (in general). **A** – the sites dated at the Roman period (the Przeworsk Culture); **B** – the sites dated at the Medieval (early and late period); The number of sites in the environs: **I** – 1, **II** – 2 to 4, **III** – 5 to 8, **IV** – 9 to 12; **V** – the site of collecting of the profile

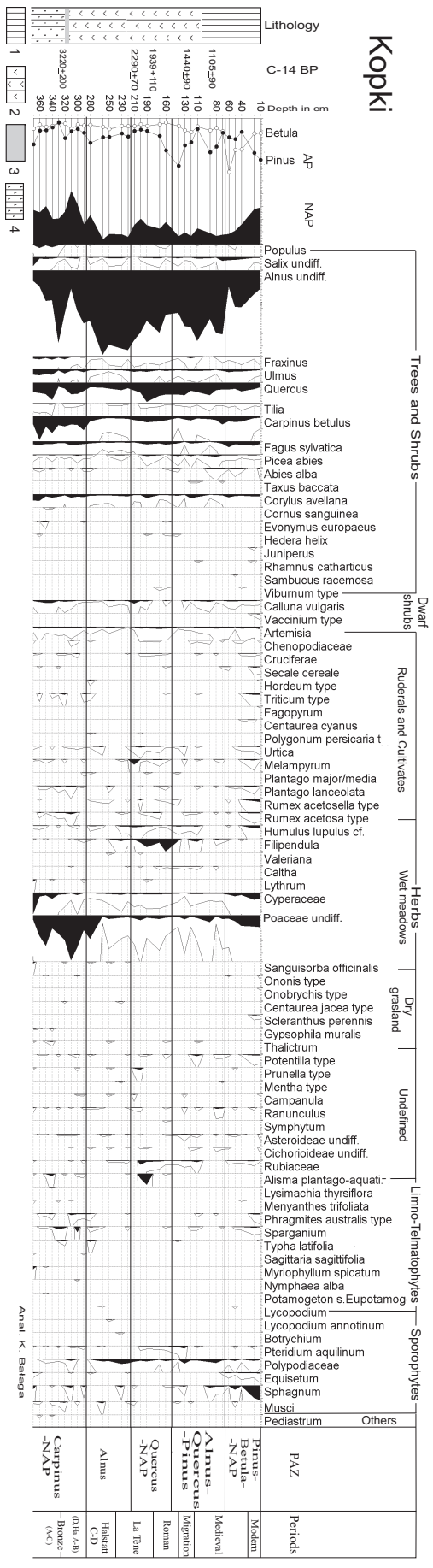

Fig. 4. A percentage pollen diagram of the Kopki profile. **1** – sedge peat, **2** – wood-sedge peat, **3** – silt, **4** – sedge peat with silt

the San river valley near Kopki. Five pollen zones (as biostratigraphical items or "pollen assemblage zones" (Birks & Berglund 1979) compared to chronozones sensu Mangerud et al. 1974) have been distinguished in the examined profile (Fig. 4).

DESCRIPTION OF POLLEN ZONES

***Carpinus*-NAP PAZ** (370–270 cm). The following mesophilous tree species reach highest frequency: *Carpinus* (3.6–18.5%), *Quercus* (3.5–13.5%) and *Alnus* (8.5–24.5%). *Carpinus* curve reaches here its maximum. The values of *Ulmus* (4.5–0.6%), *Fraxinus* (2.3–0.3%) and *Corylus* (5–0.9%) decrease in the upper part of the zone. The frequency of *Tilia* (0.1–0.9%), *Abies* (0.1–0.3%), *Picea* and *Acer* are low. The substantial peaks (up to 2.3%) of *Populus* curve occur in the lower part of the zone. The values of NAP are high. NAP curve consist mainly of Poaceae undiff. Human indicators, such as Cerealia, *Plantago lanceolata*, *Rumex*, *Urtica* are present. Aquatic taxa have also been found.

The zone limit is indicated both by the decrease of the frequency of *Quercus*, *Carpinus* and NAP and the increase in *Alnus*.

Alnus PAZ (270–215 cm). The characteristic feature of this zone is a huge peak of *Alnus* curve (55–67%). It may have caused the decrease in the frequencies of the mesophilous species: *Quercus* (6.0–3.8%), *Carpinus* (1.8–1.2%), *Fagus* (<1%), *Ulmus* (1–0.2%). Herbaceous taxa also decrease. The values of Polypodiaceae spores reach up to 1.4% in the upper part of the zone.

The zone limit is indicated by the decrease in *Alnus* and the increase in NAP.

***Quercus*-NAP PAZ** (215–150 cm). In this zone the values of herbaceous taxa, such as Poaceae undiff., *Melampyrum*, *Urtica*, *Pteridium*, *Plantago major/media*, *P. lanceolata* and Cerealia increase. The values of *Quercus* (7.5–15%), *Fagus* (1.5–2.6%), *Carpinus* (3.1–4.6%) and *Ulmus* (up to 1.7%) get slightly reduced. The frequency of *Alnus* falls considerably. NAP values increase.

The zone limit is indicated by the decrease in NAP.

***Alnus-Quercus-Pinus* PAZ** (150–65 cm). The values of *Alnus* (34–56%) and *Pinus* (up to 38%) increase. The older part of zone is characterized by higher values of pine, and the

younger one – by higher frequency of *Alnus* and Poaceae undiff. The values of *Quercus* are stable. Single pollen of *Taxus baccata* is recorded. Polypodiaceae curve rises. Anthropogenic indicators occur sporadically.

The zone limit is indicated by the increase in *Carpinus*, *Fagus* and NAP.

***Pinus-Betula*-NAP PAZ** (65–10 cm) begins with continuously increasing values of herbaceous taxa (Cyperaceae, Poaceae undiff.) and anthropogenic indicators (*Artemisia* 1.8%, Cerealia 1.5%, *Rumex* 2.7%). The curves of *Carpinus* (4.2–1%), *Ulmus* (2.1–0.5%), *Alnus* (20–14.5%) decrease.

CHANGES OF VEGETATION

Carpinus NAP PAZ (3760–2630 BP) corresponds to the late Subboreal chronozone, when mixed oak-hornbeam forests with contributions of beech, elm, lime, fir and hazel occupied fertile and moderately wet soils in the Kopki environs. Hornbeam reached its maximum. In general strong deforestation probably favoured the spread of hornbeam, beech and fir, which could more easily enter forest communities destroyed by man (Ralska-Jasiewiczowa 1980, 1981, Harmata 1995, Noryśkiewicz 1995, Ralska-Jasiewiczowa & van Geel 1998). On the other hand, the decrease of *Carpinus* curve noticeable in the ealier stages of the zone is probably connected with the settlement intensification, particularly in hornbeam-reach region of this area. As evidenced by the low proportions of fir and spruce, they were only additional components to the forests of that time. Though we should remember that fir and spruce are low pollen-productivity trees. The proportion of their pollen in the spectra in question, does not go beyond 1%. Beech was a much more numerous component of the forests. More fertile, strongly wet soils on the San river floodplain were probably covered by the remnants of riverside elm, ash-alder and willow-poplar carr, which must have occurred abundantly in the Sandomierz Basin in the preceding periods (comp. Mamakowa 1962, Nalepka 1995). Fertile sands of the Holocene higher terrace were occupied by pine-oak forests. Open pine wood with *Calluna vulgaris*, *Melampyrum* and *Pteridium* in undergrowth occurred on poor dune sands of the Pleistocene terrace. The high total herbaceous curve and presence of anthropogenic indicators evidenced a considerable deforestation in that period. Within the palaeomeander, aquatic and reedswamp communities contained *Alisma plantago aquatica* and *Sagittaria sagittifolia*. The accumulation of silty-peaty deposits, and, in time, of wood-sedge peat deposits is an indicator of the water-level fluctuations. Changes of hydrological regime in the San valley during the younger Holocene, were, according to Szumański (1986), caused by the changes of precipitation in its catchment. The accumulation of the mineral layer occurring at the depth of 312–317 cm was probably connected with flood waters. This short sedimentation change is marked in the diagram mainly by the decrease of *Alnus* and the rise of Poaceae undiff., i.e. by the change in the occurrence of local species.

Alnus PAZ (2630–2190 BP) belongs to the early Subatlantic chronozone in which the San river valley was occupied by alder communities. Elm was less and less significant in the riverside forests. *Populus* also occurred in low frequencies. Therefore, it seems that after a strong decline caused by human impact the riverside forests were not able to regenerate fully. In the representation of deciduous forests the curve of hornbeam declined to 1.2%. Solely *Quercus*, however to a lesser extent, was the main component of deciduous and mixed forests. The high frequency of local *Alnus* pollen during this zone influenced the percentages of other taxa. This is shown in Fig. 5 where selected pollen curves are recalculated with the exclusion of *Alnus*. In general all curves are higher, and we can clearly see the distinct peaks of *Pinus* curve, which can be explained by the rapid expansion of this species also on more fertile and wet soils. The decreasing values of anthropogenic indicators can provide evidence for a settlement retreat from the very swampy San river valley. The Wisłoka and Ropa valleys were also very wet then; sands and gravels with fossil trunks found there were dated to the period between 2700 and 2200 years BP (Starkel 1981).

The changes recorded in the *Quercus* NAP PAZ (2190–1660 BP) were probably connected with the climatc change towards drier conditions (evidenced by a decline of alder communities and higher proportions of oak, hornbeam and beech in forests), and also with a settlement return. The distinct peaks of *Calluna vulgaris* and *Melampyrum* occurring at the

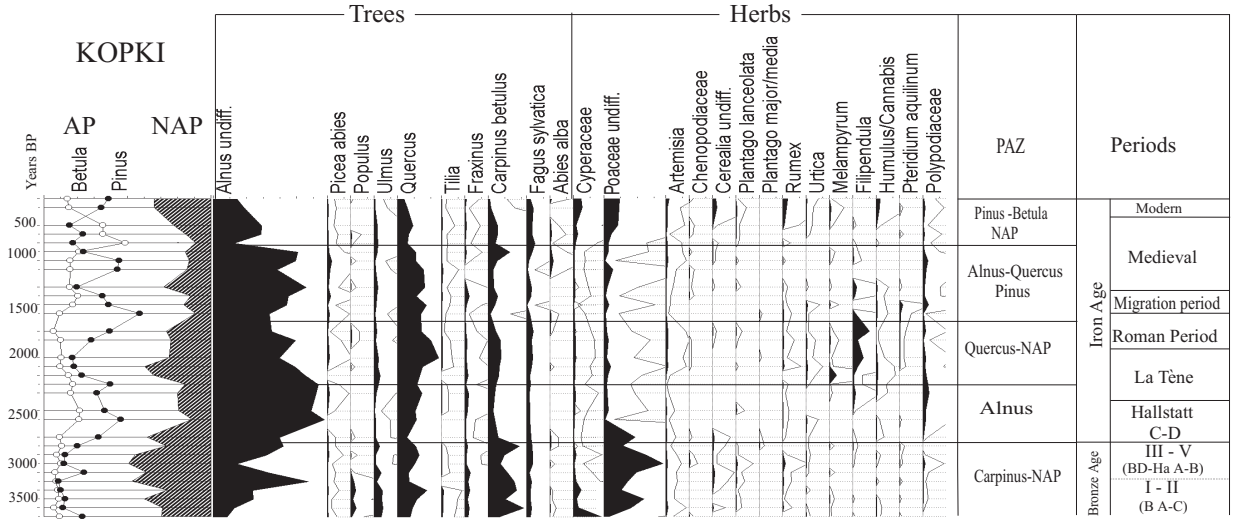

Fig. 5. A simplified pollen diagram of a few selected curves after excluding *Alnus* from total sum

beginning of this zone indicate that these species rapidly entered leached soils in the open pine forests (Ralska-Jasiewiczowa 1966, Ralska Jasiewiczowa & van Geel 1998). The increased frequency of *Artemisia*, *Urtica*, Chenopodiaceae and *Plantago lanceolata*, and the low values of Cerealia indicate that the San River valley was used as a pasture. The peaks of *Humulus/Cannabis*, *Filipendula* and Rubiaceae can be the evidence of the development of tall herbaceous vegetation as a result of clearing alder forests.

In the *Alnus-Quercus-Pinus* PAZ (1660–710 BP) the total amount of NAP decreased. This zone corresponds to the periods of Migration of Nations and the early Middle Ages. In the San River valley, the regeneration of alder communities is clearly visible. The increased frequency of hygrophilous alder could be connected with wetter climate. The peak in the *Pinus* curve at the beginning of this zone can indicate that former settlements were abandoned, and their grounds occupied by pine communities with abundant *Pteridium*, and next by pine-oak forests. Small fluctuations of the hornbeam, elm, beech or hazel curves, and a sporadic occurrence of anthropogenic indicators could reflect still existing though decreasing human impact. The short increase of the NAP frequency (about 1310 BP) is difficult to interpret. According to archeological research, this increase is not reflected in the character of the settlement which continues to increase and is not stable until the 10th century.

The changes in the landscape of the San river valley are documented in the pollen spectra of *Pinus-Betula* NAP PAZ (710–0 BP) from the late Medieval period onwards. The willow and birch thickets replaced alder forests. The frequency of birch increased to 43%, and of *Salix* to 2.2%. The same phenomenon occurred in the frequency of elm and ash, due to conducive development conditions. However, these communities did not last long. Increasing contribution of meadows and mire type-vegetation to the landscape document the gradually declining curves of *Betula*, *Salix*, *Ulmus* and *Alnus* and the rising curves of NAP, Cyperaceae, Poaceae undiff. and *Sphagnum*. Mesophilous species such as *Carpinus*, *Fagus* and *Ulmus*, being the essential component of the forests covering the higher terraces, are forced out from their sites by expanding pine. It was probably caused by the development of human economic activities, which is reflected in the diagram by the increased total values of the herbaceous and anthropogenic taxa. The systematically increasing frequency of weeds (*Melampyrum and Rumex acetosella*) from about 500 BP, growing on infertile, deforested soils suggest that settlement spread also on poorer soils.

THE ANALYSIS OF SETTLEMENT PHASES

The human influence on the vegetation is shown in Fig. 5, which is a simplified diagram composed of a few selected curves. The older

part of the pollen diagram (*Carpinus*-NAP) corresponding to 3800–3350 BP characterized by the increased values of herbaceous plants records the deforestation of the area. The evidence of human economic activities in this area includes occurrence of *Artemisia, Plantago lanceolata* and Cerealia. According to archaeological research the settlement dynamics in the examined area at the beginning of the Bronze Age was similar to that of the Neolithic Period. A small number of the Mierzanowicka Culture settlement groups occupied this area. The Trzciniecka Culture settlement was more intensive. Settlements of the Trzciniecka Culture occupy usually up to 0.5 ha ground surfaces, and provide a small amount of archaeological material (Taras 1995). The emphasis is put on the fact that the settlement character of both the Trzciniecka Culture and the Lusatian Culture was the same on the middle San and Wisłok rivers, and that the zone of great valleys was preferred by populations of both cultures (Czopek 1996a).

The strongest development of the prehistorical settlement was connected with the Tarnobrzeska Group of the Lusatian Culture, which arose here in the 13/12th centuries BC. In the studied peat profile we notice the increasing frequency of herbaceous plants including anthropogenic indicators (Cerealia, *Artemisia, Plantago lanceolata* and others) in the *Carpinus*-NAP zone (the 14–8th BC), which confirmed an escalation in the economic activities of man. Stock raising seems to have played a very important role. The agricultural populations occupied the grounds along the San River valley, concentrating mainly on the higher terraces. They preferred to settle on borderlands of adjacent zones, because one of them was suitable for the location of settlements and burial grounds, while the fertile alluvial soils of the neighbouring one facilitated effective farming (Michalski 1992, Czopek 1996a). According to archaeological date such a situation lasted till the beginning of the second half of the first millennium BC, however it does not correlate with the palynological picture, which shows rather the weakening of human activities which had taken place 200 years earlier.

The settlement situation in the Sandomierz Basin during the La Téne period was not clear. The Lusatian Culture had been developing here at least since the 4/3rd centuries BC. (Bukowski 1969, Moskwa 1976, Czopek 1996a). The time of its decline is uncertain, it may have lasted till the 3–2th centuries BC. The fact that the material of the Pomeranian Culture was found only in few sites, mainly in the western part of the Sandomierz Basin (Czopek 1992, Fig. 3) makes such presentation still more probable. It is probable that Celtic settlement spread up there too (Woźniak 1992, Fig. 2), as it is more and more frequently being discovered in the Carpathian Foothills. The settlement decline is also visible in the peat profile, in the first part of the *Alnus* PAZ zone (dated to 2630–2190±-200), where only single cultural indicators occur. Unquestionable traces of the Przeworsk Culture dated to the younger pre-Roman period (2th century BC – beginning of AD) are lacking here. However, the possibility of occasional penetrations of the Przeworsk Culture population can not be excluded, as finds from Kopki and from other sites occurring outside the examined area suggest (Wielowiejski 1973, Godłowski 1981, Kokowski 1997). In the section corresponding to this age in the pollen diagram, the signs of human activity are clearly visible. The distinct peaks of *Melampyrum, Calluna vulgaris* at the beginning of the Quercus-NAP zone evidence the clearings in pine forests. The increase in *Urtica* frequency (nitrophilous species) is the proof of the development of ruderal habitats.

The settlement of the Przeworska Culture in the 1–5th centuries AD was the first one well evidenced in southeastern Poland. This population occupied the eastern and middle parts of the Sandomierz Basin during the Roman period (1–4th centuries), and in the early stage of the Migration Period till the latter part of the 5th century (Godłowski 1981, 1985). The middle and lower San river valley was a stretch of the Black Sea route, which was confirmed by the finds of treasures and Roman coins. Other trade routes led from the Hungarian Lowland through the Carpathian passes and along the rivers flowing from the south, e.g. from the Łupków Pass along the Wisłok river to the San river. The existence of the route along the San river was probably stimulating for the settlement development and the economic growth of this region – archaeological sites on the middle San and Wisłok rivers occur close to one another. People lived here in large, open settlements which occupied sometimes several hectares, e.g. in Ko-

ziarnia (Szałapata 1963), and in which the traces of various types of production have often been found. At that time iron products became widespread, both those made from the high quality raw material from the Holy Cross Mts and those from the local meadow ores. Iron articles – arms, tools, jewellery – occur commonly in graves, e.g. in Kopki (Jamka 1936).

In the pollen diagram, the level of Quercus corresponds to the early Pre-Roman and the best part of the Roman Period. The strong decrease of Pinus curve (Fig.4) and the distinct peaks of *Calluna vulgaris* and *Melampyrum* in the *Quercus* NAP zone of the pollen diagram indicate the increasing influence of ruderal plants (*Artemisia, Rumex, Urtica*). The single grains of Cerealia (including *Secale cereale*) are noticeable. The higher pollen frequency of deciduous trees (*Quercus, Carpinus, Fagus*) are probably connected with their better flowering conditions due to the deforestation of vast areas. The increase of oak curve is recorded also in other sites. According to Ammann (1989), it is caused by the fact that in the period of Roman influence, free-growing oaks were protected because their acorns were used as animal feed.

People migrations, initiated at the end of the 4th century and lasting throughout the 5th century, took place also in south-eastern Poland, and the Early Slav population, among others, arrived from the east at the and of the 5th century. However, similarly dated archaeological material has not been found in the Kopki area. Traces of the settlement from the oldest Slav level (5/6–7th centuries) have been found in Grodzisko Dolne (however beyond the stipulated limits of the analyzed site) (Podgórska-Czopek 1991). The palynological data indicate the weakening of the human economic activity (since 1480–1310 BP).

Most of the early Middle Ages settlements, dated at the 10–13th centuries, were established on the Holocene higher terraces of the San and Wisłok rivers and their tributaries. A system of stronghold organisations gradually developed during the early Middle Ages. The stronghold – an administrative, economic, cultural and religious centre – was surrounded with a system of open settlements and burial grounds. The undated stronghold in Grodzisko Dolne probably played such a role. In the examined area the remains of the stronghold in Krzeszów, and the supposed one in Bystre should be taken into consideration. It is quite possible that “Kopiec Zbójenka” in Sarzyna is conical remainder of a stronghold (Kunysz 1966a). However, the main form of a settlement during the early Middle Ages were the open settlements of rural type, e.g. in Sarzyna (Kunysz 1966b, Czopek 1996b), in Bieliny and others.

Settlement concentration in the early Middle Ages was influenced by geographical factors and also by economic and defensive needs which triggered the formation of a system of fortified settlements. The Sandomierz primeval forest could, to some extent, delay the settlement development, but it also provided all kinds of raw materials and was excellent refuge for people. In the 12–13th centuries, Ruthenian settlers arrived from the east to the San river valley, and from the middle of the 14th century, after the incorporation of Red Russia to Poland, king Casimir the Great began an intensive colonization of this area (Kunysz 1966b). It is not reflected in the pollen diagram until 700±90 BP when the regular increase of NAP value, even more intensive since 500 BP evidences deforestation progress and increasing human activity. Ruderal plants (*Artemisia, Urtica*, Chenopodiaceae) and meadow plants (*Rumex, Potentilla*, Poaceae undiff., Cyperaceae, Rosaceae) were spreading. Among crop plants, *Triticum* and *Secale cereale* pollen distinctly predominate in the Cerealia total. *Centaurea cyanus* occurred within these crops. *Fagopyrum*, which has been recorded in the Sandomierz Basin in the deposits of the older part of the Subatlantic period (Mamakowa 1962), occurs only in the top part of the examined profile. The increase of *Rumex* and *Melampyrum* indicates a progressive podzolization of soils.

CONCLUSIONS

The most intensive settlement development in the primeval history of the Sandomierz Basin was connected with the Trzciniecka Culture and the Tarnobrzeska Group of the Lusatian Culture, and occurred in the younger part of the Subboreal period. The pollen diagram evidenced strong deforestation. Mixed oak, hornbeam and beech forests, with lime and elm admixtures and with rare fir distinctly

predominated in the Kopki environs at athat time. environs at that time. Strongly wet soils on the San riverside were occupied by the remnants of ash-alder and willow-poplar riverside carr (*Carpinus*-NAP PAZ). The palynological data evidence the existence of pastures and traces of cultivation. Since about 2840±200 years BP the values of mesophilous trees (mainly *Carpinus*) had been decreasing in mixed forests. The vast, swampy San river valley was occupied by alder (*Alnus* PAZ). Settlement declined during the 4/3rd centuries BC and the next phase of its development came about the beginning of AD, when the Przeworska Culture was spreading here. Traces of this early Roman increase of settlement are well visible in the Carpathian Foothills and in the southern part of the Sandomierz Basin. However, in the Kopki environs, they are not so distinct as the Tarnobrzeska stage. In the peat profile this period was characterized by the increase of species connected with the clearing of pine forests (*Melampyrum* and *Calluna vulgaris*) and of ruderal plants (*Artemisia, Urtica*), the occurrence of *Plantago lanceolata* – an indicator of pastoral farming, and low frequency of cereals. Vegetation cover changes probably resembled those, which had happened several centuries earlier but they took place in the already modified environmental conditions. Intensified economic activities resulted in a continual transformation of the environment. Pine-oak woods were then the dominant forests. Among deciduous trees oak remained the most stable component of forests. The next peak of synanthropic plants (after that of the Tarnobrzeska Culture) occurred in this period. The decline of the Przeworska Culture in the 4/5th centuries AD was marked by a short settlement break, yet another regeneration of alder communities and the decrease in the frequency of NAP. The gradual increase in the frequency of NAP was recorded in the early Middle Ages. The increased frequency of the anthropogenic indicators were recorded in the pollen diagram.

The continual increase of human activity in the Sandomierz Basin did not start until the end of the 15th century. The San river valley was then occupied by willow and birch thicket with increasing proportion of alder.

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