Archaeological sites in the Katynka river basin (Smolensk Region): Paleogeographic study

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Abstract. The first results of paleogeographic study at estuary of the Katynka river allow to reconstruct the dynamics of vegetation in this part of the Dnieper floodplain for about 5 millennia and identify some traces of Neolithic, Early Iron Age and Medieval human activity. The most prominent anthropogenic transformation of landscapes (signs of slash-and-burn agriculture) was associated with the late Holocene «Gnezdovo» buried soil dated 2-5 centuries AD.

1. Introduction

The Katynka river (right tributary of the Dnieper) originates in lake Kuprinskoe. Its’ lower reaches are a standard for an archaeological microregion in the Smolensk region (Fig. 1). There is a particularly high concentration of archaeological sites (more than 20 settlements on a stretch of the river valley in 5 km), dated since Mesolithic until Middle ages [1-6]. Many burial mounds of the 11-13 centuries are also located there, which makes cross-cultural and diachronic comparisons especially tempting and possible.

The main unsolved questions in local archaeology are the cultural attribution of Neolithic monuments, the correlation of terminology adopted in Belarus, Moscow and St. Petersburg; the chronology of Neolithic findings according to radiocarbon dating; the specifics of agriculture and economic activities. In paleogeography it is relevant to fill temporal and spatial gaps in paleovegetation and paleoclimate data to describe its’ dynamics for the whole Upper Dnieper region during Holocene and its connection with population waves and economic activity.

Unfortunately, there is critical lack of complex archaeological and paleoecological studies in the Dnieper valley. Most studies are focused on the Gnezdovo archaeological complex (the largest monument of Viking age) located on the right bank of the Dnieper, in 4 km to the East from the outfall of the Katynka river. However, the detailed reconstructions are limited to the surroundings of the archaeological complex (the estuary of the Olshanka river and the Svinets river) and reflects only the last 2 millennia [7-9]. Other studies are focused on Dnieper river channels and their temporal modifications [10, 11]. Vegetation and climate reconstructions for the entire Holocene in the Dnieper floodplain or in the Smolensk region still have not been published.

The aim of current study was to continue paleolandscape research in the neighboring Gnezdovo area of the Dnieper valley which is characterized by an exceptionally high concentration of archaeological sites. A comprehensive archaeological and paleogeographic study of the Katynka river basin was started
in 2017 [12]. Our studies continue the series of the archaeological explorations and excavations since the 1920s A. N. Laudanski, A. E. Schmidt, V. P. Tretyakova, I. M. Tyurin, V. S. Nefedov [1-6]. The project was initiated by scientists from the Institute of Archaeology RAS (Moscow), Faculty of Geographical Sciences of the University of Lodz (Poland) and the faculty of biology of Lomonosov Moscow State University (Moscow).

Figure 1. The monuments in the valley of the Katynka river. Studied area marked with red triangle.

Figure 2. The location of the archaeological test pits. (photo by I. Boytsov).

Figure 3. Scheme of the structure of the floodplain sediments at the mouth of the old riverbed Katynka.

2. Materials and methods
The first stage of the project was the study of the estuary section of the Katynka valley between the Vitebsk highway and the Dnieper (Fig. 1). The paleo-channel of the Katynka river is located in 400 m to the West from the current channel, it was chosen for the study. This oxbow depression supposedly contains organic sediments which potentially may provide "archive information" about the past. The paleo-channel of the Katynka river cuts the high floodplain of the Dnieper, having elevations up to 9 m. During high water, almost the entire floodplain is flooded, with the exception of the levee, on which the burial mound dated 11-12 century AD is located (part of the group VIII [1]).

In total, 9 archaeological pits and one trench were investigated. In addition, 11 points were selected along the transect and drilled using soil sampler to obtain specimens. Chosen trajectory of the transect
crossed the Katynka old riverbed and the burial mound located on the levee (Fig. 2 and 3). Samples were taken from oxbow sediments and buried soils for analysis.

2.1. Pollen and phytolith analysis

20 soil samples were collected from stratigraphic layers of the archaeological pits S1, S2, S3, S8. 40 samples were also collected at 5–10 cm intervals from the sediment core KT5. They were processed in the Department of Ecology and Geography of Plants MSU by a standard method using acidification with 10% HCL, boiling in 10% KOH, centrifuging with heavy liquids (sodium polytungstate), acetolysis [13] with the addition of the Lycopodium marker [14]. Pollen identification and taxonomy follows [15, 16] and reference collection (http://botany-collection.bio.msu.ru). Counting was done using a light microscope with a magnification from 400 to 1000x with the identification of 300–400 pollen grains of terrestrial plants per sample. In cases of low pollen concentration, about 200 pollen grains were counted if possible. Beside pollen, the samples were examined for the presence of the phytolith morphotypes diagnostic of Cerealia (dendritic) and Panicum (panicoid) [17, 18]. Diagrams were constructed with the use of TILIA and TILIA-GRAPH software [19]. The percentage of pollen taxa was calculated as a percentage of total pollen grains, and the percentage of spores as a percentage of the total number of pollen and spores.

2.2. Radiocarbon dating

Peat and sapropel samples and charcoal fragments from soil were dated in the Marek Krńpiec Laboratory of Absolute Dating (Skala, Poland; MKL) and in the A.E. Lalonde AMS Laboratory (University of Ottawa, Canada; UOC) using accelerator mass spectrometry. Calibration was performed using OxCal v.4.1.7 software with the IntCal13 calibration curve and probability intervals of 68.2 and 95.4% [20, 21].

3. Results

3.1. Stratigraphy and radiocarbon dating

The study reveals several separated layers associated with human activities. Most of these layers were found in the estuary section of the Katynka river in the alluvial deposits of the Dnieper. At the same time, only one well developed buried soil was identified clearly. This soil was found in the most studied archaeological pits at a depth of about 1 m from the modern surface. The base of the burial mound dated 11-12 centuries AD is located on its surface (Fig. 3, 4). The buried soil has evidences of forest soil formation considerably transformed by human activity and is rich in coal. Dates obtained using AMS for these coals are 1603±89 cal yr BP, 1606±41 cal yr BP, 1818±43 cal yr BP (Table 1). Presumably, this buried soil is synchronous to the one described earlier on the territory of the Gnezdovo archaeological complex [8], so we called it "Gnezdovo soil". Its surface has a slope to the North, deepening from the area of the Dnieper riverbed to the Katynka paleochannel.

The charcoal layer was traced in alluvium about 1 m below the "Gnezdovo soil" in pit S1, it was dated 3330±90 cal yr BP (Table 1), i.e. 1700-1500 BC (Bronze Age). The strongly rounded fragments of Neolithic ceramics were found in the alluvium under the "Gnezdovo soil" in several pits (S1, S3, S8). They were not associated with a specific soil surface; probably, they were redeposited. A brief description of archaeological pits S2 and S3 is given in Fig. 4 and 5. Description of the archaeological finds published in Krenke et al, 2018 [12].

In the old riverbed depression (borehole KT5) "Gnezdovo soil" overlays the 3 m of organic-rich material (peat/sapropel). 5 radiocarbon AMS dates (Table 1) were obtained for the sediment core. The dates demonstrate that the accumulation of sediments took more than 5 thousand years. These sediments are perspective for paleoreconstructions due to the undisturbed stratigraphy.
Figure 4. Archaeological pit S2. 1 – brown sand, mixed plowing; 2 – gray-brown sand (buried underdeveloped soil); 3 – dark gray-brown sand with inclusions of charcoals and baked clay – "Gnezdovo soil" with archaeological findings; 4 – yellow alluvial sand; 5 – light gray-brown sand (underdeveloped soil); 6 – brown sand with white lenses.

Table 1. \(^{14}\)C dates from Katynka floodplain

| Sample description, Depth | Dated material | Lab code     | \(^{14}\)C yr BP (1σ, 68.2%) | cal BP | cal BP (2σ, 95.4%) | Mean(μ)±σigma(σ) | cal BP |
|--------------------------|----------------|--------------|-----------------------------|--------|-------------------|------------------|--------|
| Katynka, KT5 -70-75 cm   | peat, humified | UOC-10728    | 2997±59                     | 3322 - 3075 | 3350 - 3002 | 3177±92 | 3178   |
| Katynka, KT5 -125-130 cm | sapropel       | UOC-6364     | 3639±27                     | 3982 - 3905 | 4080 - 3871 | 3957±50 | 3949   |
| Katynka, KT5 -190-195 cm | sapropel       | UOC-6365     | 3866±28                     | 4403 - 4239 | 4413 - 4160 | 4303±63 | 4301   |
| Katynka, KT5 -240-245 cm | sapropel       | UOC-6366     | 4217±32                     | 4843 - 4709 | 4854 - 4629 | 4757±64 | 4746   |
| Katynka, S1 -130-135 cm  | charcoal       | MKL-3629     | 1690±70                     | 1699 - 1531 | 1806 - 1412 | 1603±89 | 1602   |
| Katynka, S1 -215 cm      | charcoal       | MKL-3630     | 3330±90                     | 3685 - 3455 | 3826 - 3380 | 3576±109 | 3570   |
| Katynka, S3 -187-195 cm  | Picea charcoal | UOC-5857     | 1697±26                     | 1618 - 1559 | 1695 - 1544 | 1606±41 | 1597   |
| Katynka, S3 -200-210 cm  | Quercus charcoal | UOC-5858   | 1878±27                     | 1874 - 1742 | 1881 - 1731 | 1818±43 | 1827   |

3.2. Pollen and phytoliths analysis

3.2.1. Archaeological sections. Pollen was found just in part of samples from soil pits due to poor pollen preservation in alluvium [22, 23]. Nevertheless, in pits S2 and S3 it was possible to extract a sufficient number of pollen grains from the buried "Gnezdovo soil" (Fig. 5). Obtained pollen and phytolith spectra were similar in all samples. They are characterized by: 1) absolute predominance of Betula pollen; 2) abundance and diversity of herb pollen, which includes both meadow and ruderal taxa and typical forest species characteristic of forest post-fire successions (Onagraceae, Pteridium); 3) poor but constant presence of cultivated cereals; 4) presence of panicoid and dendritic phytolith morphotypes. In archaeological pits S1 and S8 which contained Neolithic finds, pollen was not found.
3.2.2. Oxbow sediments (KT5). The results of pollen and radiocarbon analysis of sediments from the core KT5 are presented in Fig. 6. The pollen diagram includes 4 contrasting local zones (LPZ) which reflect stages of vegetation development in the Dnieper floodplain.

LPZ 1. 290-375 cm, before 4.8 ka BP, the functioning time of the old Katynka channel. 90-95% of the extracted pollen belongs to deciduous trees (Alnus, Betula, Ulmus, Quercus, Tilia), the presence of Picea is low. Herbaceous pollen is less than 10% of total pollen spectra, but some meadow herbs (Poaceae, Filipendula, Fabaceae, Asteraceae) and some indicators of anthropogenic disturbances (Artemisia, Cichorium, Rumex) as well as microscopic charcoals were found. These evidences may indicate the activities of the Neolithic population.

LPZ 2. 70-290 cm, 4.8-3.0 ka BP, woody peat and peaty sapropel - former riverbed becomes a swamp. Quercus is a dominant in the pollen spectra (40-60%) with a small admixture of Alnus, Ulmus, Tilia, Corylus. The composition of herbaceous pollen (Sparganium, Comarum palustre, Filipendula, Urtica) indicates the habitat as wet and eutrophic. After 3.0-2.8 ka BP the peat ceased due to the drying out of the swamp. There are signs of fire disturbances (Onagraceae pollen, Chenopodium pollen, Lycopodium spores, microscopic charcoal) in the layer just below the date 3177±92 cal yr BP. That layer is probably correlating with the Bronze age charcoal layer from archaeological pit S1.

LPZ 3. 30-60 cm, 2.5-0.8 ka BP, buried "Gnezdovo soil". The pollen composition changes dramatically. Pollen of indigenous forest trees (Quercus, Ulmus, Tilia) disappears almost completely. Dominants are Betula (up to 40%) with admixture of Pinus. Microscopic charcoals, Onagraceae pollen and Marchantia spores indicate fires. Pollen of meadow herbs (Galum, Apiaceae, Ranunculaceae, Lamiaceae, Filipendula, Caryophyllaceae, Asteraceae, Fabaceae, Cyperaceae), weeds (Centaurea cyanus, Polygonum aviculare, Artemisia, Xantium, Asteraceae sbf. Cichorioideae) and Cerealia is also present. In addition, the soil is rich in microscopic charcoal and charred phytoliths, among which there are many panicoid and dendritic forms characteristic of cultivated cereals. Presence of Sphagnum,
Lycopodium, Pteridium spores increases sharply. Similar spectra were found in samples from the buried "Gnezdovo soil" in archaeological pits S2, S3 and S8.

Figure 6. Pollen spectra of buried «Gnezdovo soil». The percentage of pollen taxa is calculated as a percentage of total pollen, and the percentage of spores as a percentage of the total number of pollen and spores.

LPZ 4. Modern meadow soil formed over the past few centuries on the river alluvium overlying the "Gnezdovo soil". Pinus pollen (up to 75%) dominates in the arboreal pollen spectra with a small admixture of Betula and Alnus. Taxonomic diversity and presence of meadow herbs, weeds and cultivated taxa pollen increases significantly (up to 30%). Spores of ferns, lycopods and mosses, among which there are many ancient redeposited forms, are well presented in the spectra; it is usual for alluvial soils. Riccia glauca spores, which is an indicator of overgrown arable land [24], are noted in the upper horizon of the soil.

4. Discussion
The first results of paleogeographic study at estuary of the Katynka river allowed to present the stratigraphic sequence of floodplain deposits and associated archaeological finds, as well as to reconstruct the dynamics of vegetation in this part of the Dnieper floodplain for about 5 millennia. It is
shown that for a long time – from the beginning of oxbow lake overgrowing about 4.8 ka BP and to its drying – floodplain oak forests were widespread here, in which *Alnus glutinosa*, *Ulmus*, *Tilia* and *Corylus* were presented. *Humulus* and various herbs indicators of wet and nitrogen-rich habitats were presented under the trees’ canopy. At the end of this period (about 3.0 ka BP) the oxbow lake had become a swamp and dried up. The soil was formed in place of the dried-up old riverbed; it can be traced in all the studied pits. The surface of this soil is confined to the findings of medieval time. In the future, increased flood activity led to the burial of the soil under alluvium. That factor formed the modern meadow soil.

The data of paleobotanical analyses allowed us to identify some traces of human activity of the Neolithic population in the floodplain of the Dnieper (charcoal, pollen of ruderal plants). However, the most prominent anthropogenic transformation of landscapes is associated with the formation of the late Holocene "Gnezdovo soil". The simultaneous combination in one spectrum of taxa belonging to different ecological and cenotic groups indicates that the "Gnezdovo soil" contains the traces of several successive stages of vegetation development – repeated cycles of deforestation and their subsequent partial restoration. High concentration of phytoliths, including charred, indicates that the soil has passed through multiple fires. In addition, most importantly, in all analyzed samples of "Gnezdovo soil" panicoid morphotypes were identified, which are specific to grasses of the subfamily Panicoideae. In our region only cultural species millet can belong to this subfamily. Recent studies have shown that this combination of pollen and phytolith spectra, as well as the saturation of the soil with small charcoals, is characteristic of the slash-and-burn farming [25].

Radiocarbon dates obtained for some of the charcoals from the "Gnezdovo soil" gave a fairly large spread: 1818±43 cal yr BP (oak charcoal), 1603±89 cal yr BP and 1606±41 cal yr BP (spruce charcoal), which indicates the repeated deforestation through the burning. Similar pollen data were previously obtained for buried "Gnezdovo soil" at other points in the Dnieper floodplain: Olshansky hillfort [12, 26], burial mounds of the Gnezdovsky archaeological complex [27] and Cathedral Mountain (Sobornaya Gora) in Smolensk [28, 29].

Thus, the results of our study confirm the earlier conclusions about the large-scale transformation of the landscapes of the Dnieper valley, in particular, the reduction of indigenous forests through multiple burning (slash-and-burn millet farming) long before the existence of Gnezdovo and ancient Smolensk.

The paleoecological data corresponds to the new interpretations of the previous archeological studies. According to them the ancient center of the region was situated on the hillfort Demidovka located 2 km south from Gnezdovo and Katynka river in the 1st Millenium AD [6, 30]. Probably that was a residence of the local noble of a suppositional little German-Slavic kingdom. Silver jewelry including the folding belt, sulfur-coated pottery of the Chernyakhov culture and abundance of weapon and riders’ equipment were found there. The last stage of Demidovka settlement was dated 1460±70 cal yr BP [30]. Our radiocarbon and pollen data show that this compact period (5 - 1st half of 6 centuries AD) was undoubtedly also the period of the intensive agricultural activity in Upper Dnieper basin valleys.

The next stage of the agricultural activity appeared in 8-10 centuries AD near the Cathedral Mountain (Sobornaya Gora) in Smolensk [28, 29]. In the 9-10 centuries the center had shifted down the Dnieper valley to Gnezdovo [7, 8, 9, 10], then it moved back to the territory of modern Smolensk.

To sum up, according to archaeological studies there was at least 3 stages of agricultural development in the Smolensk region in the 1st Millenium AD. Current data obtained by pollen analysis doesn’t allow to separate or compare these stages, but it may be possible to isolate pollen signals in narrower time intervals in our future studies.

5. Conclusion

The multiproxy approach considering paleoecological and archaeological data allowed us to reconstruct the vegetation and agricultural history of the Dnieper valley near the estuary of the Katynka river for 5 millennia. The most prominent cultural transformation of landscapes (signs of slash-and-burn agriculture) was associated with the late Holocene «Gnezdovo» buried soil. The radiocarbon dates obtained for this soil at different points of the Dnieper valley indicate several periods of deforestation.
that can be associated with various cultures that inhabited the valley in the 1 Millennium AD. The beginning of the mass destruction of floodplain oak forests in the 2-5 centuries AD may relate to the agricultural activity of the German-Slavic settlement Demidovka on the left bank of the Dnieper. The study allowed to reconsider the importance of further archaeological and interdisciplinary studies of the Dnieper Valley.

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