GEOMORPHIC PROCESSES AND GEOARCHAEOLOGY
From Landscape Archaeology to Archaeotourism

International conference
August 20-24, 2012

GEOARCHAEOLOGICAL ISSUES OF THE UPPER DNIEPER – WESTERN DVINA RIVER REGION (WESTERN RUSSIA): FIELDTRIP GUIDE

Moscow-Smolensk, Russia

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Geoarchaeological issues of the Upper Dnieper – Western Dvina river region (Western Russia): fieldtrip guide.

This is the guide of two field excursions that were held during the International conference "Geomorphic Processes and Geoarchaeology: from Landscape Archaeology to Archaeotourism" (Moscow-Smolensk, Russia, August 20-24, 2012) hosted by the Smolensk University for Humanities. Excursion to the Gnezdovo archaeological complex in the Dnieper River valley in the vicinity of the Smolensk city was managed by the cooperative team from Moscow University (Faculty of History and Faculty of Geography), State Historical Museum (Moscow) and Institute of Geography, Russian Academy of Sciences (Moscow). Excursion to the Serteya complex in the Western Dvina River region was conducted by the State Hermitage Museum (Saint Petersburg).

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PART I.
GNEZDOVO ARCHAEOLOGICAL COMPLEX IN THE UPPER DNIEPER RIVER VALLEY

CHAPTER 1.1.
GNEZDOVO ARCHAEOLOGICAL COMPLEX: HISTORY OF RESEARCH AND GENERAL CHARACTERISTIC

The Gnezdovo complex of the archaeological monuments

The Gnezdovo complex of archaeological monuments is a unique cultural landscape dated to the time of the formation of the Ancient Rus'. It covers an area of 207.4 hectares (about 5300 acres). Gnezdovo has the largest early medieval cemetery known today in Europe, with an extent of studied sites greater than such well-known Viking-period sites such as Birka in Sweden and Hedeby in northern Germany. In terms of its original scale and scientific significance, the Gnezdovo complex could be compared to ancient centres such as Kiev on the Middle Dnepr or Great Novgorod in northern-western Russia. Just as the latter sites, Gnezdovo reflects the process of formation of the Ancient Rus' state, people and culture.

The population of ancient Gnezdovo was formed by the members of different ethnic groups: Slavs, being incomers from Central Europe and the Middle Dnepr region; the next incomers from Northern Europe and local tribes "Krivichy" .The archaeological finds reflecting all features of the site of Gnezdovo are in the State Historical Museum in Moscow, the State Hermitage in St. Petersburg, and the Smolensk State Museum. Evidence and results of the archaeological studies of Gnezdovo have been presented in numerous scholarly and popular publications.

A brief history of the fieldwork

The first information on the archaeological monuments near Gnezdovo village dates from 1867 and relates to the accidental finds of the Xth century hoard of silver ornaments discovered during railway construction. The scholarly studies of Gnezdovo burial mounds were initiated by the President of the Moscow Archaeological Society, A.S. Uvarov. The archaeological excavations of the mounds were first carried out by M.F. Kustsinsky in 1874, and continued by the Scientific Secretary of the Russian Historical Museum, V.I. Sizov, from 1881 to 1901. It is difficult to estimate the exact number of mounds studied in the course of this fieldwork; by some estimates, there were about 400.

In 1898-1901, some excavations were carried out by C.I. Sergeev and sponsored by the Imperial Archaeological Commission, but those works had a rescue character made necessary by the widening of the railway embankment. At the end of the XIXth century and during the first decades of the XXth century, some local excavations were undertaken by S.P. Pisarev (Smolensk), G. Boguslavsky, V.A. Gorodtsov and E.N. Kletnova. In 1905 excavations of some burial mounds and of the Ol'shanskoye hillfort were carried out by I.S. Abramov (Russian Geographical Society). The first detailed description of the entire Gnezdovo archaeological complex was presented in 1923 by A.N. Lyavdansky who discovered the contemporary Central and Ol'shanskoye settlements located on the first terrace above the flood plain of the river Dnepr.

From 1949, complex studies of the Gnezdovo site are been carried out by the Smolensk archaeological expedition of the Moscow State University Lomonosov by name which began under the directorship of D.A. Avdusin. In the years 1949-2012, about 700 burial mounds were excavated and complex studies were undertaken at the Central and Ol'shanskoye settlements. In order to trace the extent of the Central settlement cultural layer, trial excavations were carried out in 1995-96 in the area of the Dneper flood plain on the left bank of the river Svinets. These resulted in the discovery of cultural layers of the Ancient Rus' period at these new sites.

In 1967-1968, the Dnepr archaeological expedition headed by I.I. Lyapushkin studied the terrace part of a settlement on the right bank of the river Svinets. Since 1995, the Central settlement has been studied by the State Historical Museum expedition, with a particular focus on the flood plain zone.

A combined Smolensk archaeological expedition headed by T.A. Pushkina (Moscow State University) and V.V. Murasheva (State Historical Museum) has carried out complex fieldwork on the Gnezdovo site since 1998 in association with experts from the Institute of Geography (Russian Academy of Science) and the Geographical and Pedological Faculties of Moscow State University which had started work here in 1995.

As of today, some 1200 mounds in different parts of the ancient cemetery have been excavated and studied as well as nearly 7000 m² of settlement areas.

The main archaeological sites

The archaeological complex of Gnezdovo includes numerous sites with traces of various economic and manufacturing activities, defences of the central hillfort in a form of rampart and ditch, and a series of large mounds. These mounds are located in a semicircle around the central settlement and are concentrated in several groups to the east, west, north of the settlement on the right bank of the river Dnepr and to the south of it on the left bank.

The main, and most intensively studied, group of archaeological sites is situated on the right bank of the river Dnepr, near the confluence of the small river Svinets (Fig. 1.1). It is comprised of several groups.

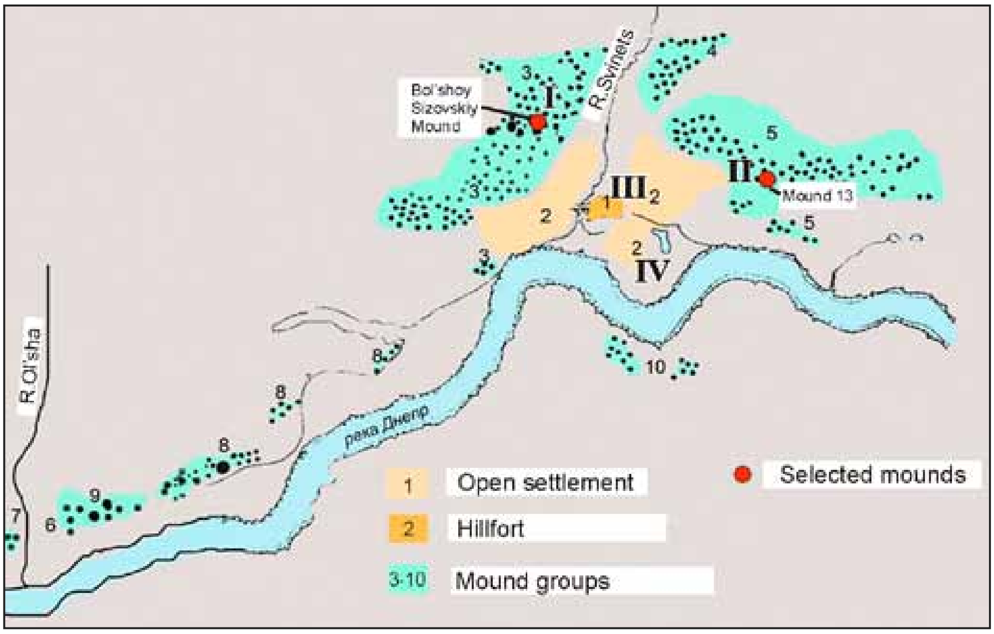

Figure 1. Location map.
Arabic numerals are mound groups; roman numerals are stops of the field excursion

(see Chapter 1.3).

The first (central) group consists of the Central hillfort and the open settlement (Fig. 1.1, *1-2*), the latter being located on both banks of the river Svinets banks at its confluence with the Dnepr. This group includes also the Central mound group (Fig. 1.1, *3*), the Glushchenkovskaya mound group (Fig. 1.1, *4*) and the Lesnaya mound group (Fig. 1.1, *5*). These groups enclose the settlement on the north-west, the north, north-east and the east.

The second (western) group of monuments is also limited to the right bank of the Dnepr but is further downstream. It consists of the Ol'shanskoye hillfort (Fig. 1.1, *6*) located at the promontory of the river Ol'shanka, and the Dnepr mound group (Fig. 1.1, *8*), the latter located nearly half way between the Ol'shanskoye hillfort and the central settlement. On the right bank of the Ol'shanka river, further downstream the Dnepr, another two mound groups are known within the western group. Those are the Transol'shanskaya group (Fig. 1.1, *9*) and the small Nivlenskaya group (Fig. 1.1, *10*). Close to the Ol'shanskoye settlement, there existed the Ol'shanskaya mound group, but it was destroyed in 1975 in the process of road building.

The third (southern) group of monuments consists of a number of mounds located on the left bank of the river Dnepr bank, above the confluence with the river Svinets (Fig. 1.1, *11*).

Mounds

The central and eastern parts of the site of Gnezdovo appear to form a peculiar settlement centre (a "core") which is characteristic of proto-urban structures of Eastern and Northern Europe in the IXth-XIth centuries. The special features of such settlements could be described by the following topographical scheme: a large open settlement with traces of economic and manufacturing activities; a small fortified centre; a necropolis consisting of several nearby cemeteries; and small satellite settlements. All these elements are present in the Gnezdovo archaeological complex, in contrast to other well-known archaeological sites of the period of early state formation of the Ancient Rus'.

The Central hillfort occupies a promontory of the first terrace above the flood plain on the left bank of the river Svinets. The open settlement is located on the terrace and on the adjacent part of the flood plain. The ditch which encloses the defended area to the east of the settlement is distinctly marked, as is a group of ramparts along its northern and part of its eastern sides. The hillfort encloses an area of 1 hectare (2.5 acres), and the total area of the central settlement is about 30 hectares (75 acres).

The thickness of the cultural layer in the terrace part of the open settlement varies from 0.2 to 0.8 m, while in the hillfort it is in the range of 0.5 to 1.5 m. Ploughing of the area in the late 1940^{s} and 1950^{s} resulted in extensive destruction of the stratigraphy of the cultural layer: in several places of the settlement, it has been completely ploughed up. Numerous war trenches as well as building pits of the 1950^{s} also damaged the occupation layers of the settlement. Flood plain settlement was preserved much better because it was covered by alluvial sediment in the XVIIIth century or later. This specific "blanket" with a thickness of 0.7 up to 3.0 m is responsible for the unique preservation of the cultural layer and protected it against anthropogenic factors. The thickness of the cultural layer on the flood plain is estimated to be 0.2 up to 0.8 m. One of the most effective peculiarities of the flood plain zone is the remarkably good preservation of organic remains, and wood fragments allowed to obtain samples for dendrochronological analyses.

The beginning of the Gnezdovo settlement is dated to the transition from the IXth to the Xth centuries, its peak development to the middle and second half of the Xth century. Its active period ended in the first half of the XIth century, but human activity in the area did not cease. Traces of a feudal residence of the XIIth – XIIIth centuries were uncovered in the area of the central hillfort and in the settlement located on the first terrace above the flood plain. Later, at the time of Polish power over the region in the XVIIth century, the area of the central settlement was occupied by the mansion of the Catholic bishop Peter Parchevsky; remains of this building were recently discovered by the Smolensk archaeological expedition. A small settlement also existed in the area of the Ol'shanskoye hillfort in the XVIth – XVIIth centuries.

Several monuments of the XVIIth century found on the left bank of the river Dnepr in the vicinity of Smolensk are closely associated with the later period of Gnezdovo history.

The results of archaeological research at Gnezdovo

The scale of Gnezdovo and its role in the early stage of the Ancient Rus' state formation was greatly determined by its geographical position at the 'apex' of the river systems linking Kiev and Novgorod. The existence of Gnezdovo opened up the possibility of the development of the Upper Dnepr region either to the west along the West Dvina river up to the Baltic, or to the east along to the Oka and Volga river basins.

The preservation and the evidence of the cultural layer at Gnezdovo varies greatly differs across the site, but we have basic data on the main types of dwelling, manufacturing and economic buildings, and have ascertained some clear trends of the site development.

Wood remains are practically absent within the cultural layer at Gnezdovo, thus the data on the house building system and corresponding architectural traditions are very scanty. The places of buildings, their size as well as the existence of hearths could be approximately identified by the location of dark, nearly black areas with coal inclusions and accumulation of burnt stones and clay within a layer. There are two distinct types of houses: one built entirely above ground, the other one with a sunken floor. Both types could be identified in the area of the settlement, but their functions were different. They were used for living, manufacturing and economic functions. The outlines of building remains and the features of the cultural layer distribution suggest the existence of some sort of tenements over a considerable extent of the eastern and flood plain parts of the settlement. The tenement borders could be traced by the distribution of boundary trenches, lines of fencing post-holes and unoccupied areas, the latter indicated by the absence of an occupation layer. An accurate estimate of tenement sizes is difficult, but it is evident that they included dwellings as well as related economic and manufacturing buildings.

Plotting the finds indicating manufacturing showed that they occur throughout the settlement area. The peculiarities of such finds and their distribution allowed the identification of several economic and manufacturing zones. Two of them were specialized metalworking zones located on the flood plain. Others (perhaps three) are associated with the terrace part of the settlement including the hillfort where raw materials, moulds and waste products of jewellery production and blacksmithing as well as traces of boneworking were identified.

The fieldwork revealed the wide range of metalworking including the production of tools, weapons and implements of ferrous metal as well as jewellery production of precious and base metals, the existence of pottery production and boneworking, and the use of silver coins as the means of payment.

The Gnezdovo craftsmen produced high-quality ferrous goods, using a complicated technology of multi-layer welding. The jewellers cast composite female ornaments in stone and clay moulds, and applied techniques of stamping and engraving. It should be pointed out that the local crafts of the 10^{th} century provide evidence of the coexistence of different manufacturing traditions, such as southern Slavic and northern Scandinavian traditions. The types of Gnezdovo pottery suggest that this settlement was a key production centre of wheel-thrown Slavic ceramics in the Upper Dnepr region.

Interdisciplinary work of archaeologists with experts from the Institute of Geography (Russian Academy of Science) and the Faculty of Soil Science (Moscow State University) uncovered ancient plough marks beneath the edges of the Dnepr mound group. The ash layer of the cremation fires at several mounds was found to be superimposed on an ancient plough horizon which could be traced as a series of distinct grey stripes against the background of the pale yellow subsoil of sandy clay sediments. Evidently some Dnepr-group mounds were erected on a previously ploughed area with the area at least 0.5 hectares (1.25 acres). The Dnepr mound group is located on a low, narrow elongated ridge along the edge of the first terrace above the flood plain. This circumstance as well as the nature of the mound distribution allowed to estimate the ancient ploughed land area to be as much as 1.5 hectares (4 acres). We suppose that this area makes up only a small part of the arable land used to supply the Gnezdovo population with grain during the IX^{th} to early XI^{th} centuries. Palaeobotanical analysis of the soil filling the furrow on the surface of the excavated plough surface showed the presence of wheat and weed pollen. Thus the inhabitants of ancient Gnezdovo were engaged in agricultural activities. This conclusion is supported by finds of some iron ploughshares within the cultural later dated to the late X^{th} – first quarter of the XI^{th} century in the flood plain part of the settlement. The existence of a wooden plough, in turn, suggests the use of draught animals.

A large number of archaeological finds from Gnezdovo indicate links to Byzantium. These finds include coins and lead stamps, complete and fragmentary amphora, white clay glazed pottery, fragments of glass vessels and ornaments, textiles and gilded threads, horn and bone items, and ornaments and utensils made of base metals. Byzantine stamps of the IX^{th} – first half of the XI^{th} century are rarities in Ancient Rus' contexts; they are known only from Kiev and two sites located on the "Road from the Varangians to the Greeks". The Gnezdovo finds include some early Christian attributes of personal piety: cross pendants made in Byzantium Their owners evidently were inhabitants or visitors of Gnezdovo in the second half of the X^{th} – beginning of the XI^{th} century.

One of burials contained an amphora from the Black Sea region with a unique Ancient Rus' inscription dated to the second quarter – middle of the X^{th} century. The burial may be that of a person of high social rank, e.g. a Varangian warrior who was engaged in trade or military service in the Byzantine Empire.

The Gnezdovo finds of Byzantine origin are the most representative collection of such artefacts from all Ancient Rus' sites of the X^{th} – beginning of the XI^{th} centuries. The inhabitants of Gnezdovo who were buried in mounds with objects of Byzantine origin may have been members of the military, merchant or diplomatic elite. The concentration of Byzantine finds at Gnezdovo suggests that it played a special role in communications with Constantinople from from the first decades up to the last quarter of the X^{th} century. The finds of lead stamps indicate direct communications with Greek officials.

The Gnezdovo burial mounds and settlements produced the largest number of finds of Scandinavian origin among all sites considered to belong to the regions of the Ancient Rus'. These finds include attributes of pagan cult, parts and ornaments of male and female dress, weapons and items of horse harness as well as domestic utensils. The majority of Carolingian swords of the Xth century found in the Ancient Rus' originate from Gnezdovo. Swords of this type would have been a valuable part of the professional warrior's equipment.

In addition, the Gnezdovo finds include numerous ornaments of types known from archaeological sites of the Upper Dnepr and Dvina regions, West Slavic lands, the Middle Dnepr region and from Volga Bulgaria.

According to the types and origins of finds, the first inhabitants of Gnezdovo were Scandinavians, Slavs and local Krivichi. This suggestion is based on the data of burial rituals, types of armour, tools and pottery. The population of the Gnezdovo settlement is estimated at 800-1000 people at the peak of its development. Thus, the size of the settlement is well above that of previous settlements and of contemporary rural settlements.

The distribution and specificities of the archaeological finds indicate the gradual development and growth of the Gnezdovo settlement, as does the development of the cemetery areas and their mound groups. The oldest dwellings and manufacturing buildings are found at the promontory parts of the terrace as well as on the Dnepr flood plain.

In the first half of the Xth century, the zone of dwellings already occupied both promontories of the Dnepr terrace. A kind of 'harbour zone' emerges on the Dnepr bank from the second quarter to the middle of the Xth century. The settlement area of increased markedly in the middle to second half of the Xth century through the spread of buildings along the edges of the flood plain and through the development of vast areas along and inside the first terrace above the flood plain on both banks. Buildings were erected even on former wasteland, e.g. in a boggy depression near the terrace on the left bank of the river Svinets which was filled with sand. The oldest grave-mounds are situated in Lesnaja group. The overwhelming majority of all burial mounds are dated to the period termed "Late Gnezdovo". The first burials of the Central group of mounds belong to the middle of the Xth century; contemporary mounds are known from the Lesnaya group. The oldest mounds of the Dnepr, Ol'shanskaya and Transol'shanskaya groups are dated not earlier than the middle of the Xth century.

All archaeological evidence of Gnezdovo suggests a multi-ethnic settlement with a highly developed social structure, and an active participation in the international trade along the "Road from the Varangians to the Greeks". Numerous objects of Byzantine import (silver and gold coins, silk textiles, glazed pottery) and 11 hoards of Arab coins and silver ornaments are strong arguments to compare Gnezdovo in the IXth – Xth centuries with settlements such as Kiev, the capital of the Ancient Rus'.

CHAPTER 1.2.
GEOMORPHOLOGY AND LATE VALDAI (VISTULIAN) – HOLOCENE HISTORY OF THE UPPER DNIEPER RIVER VALLEY

General overview

The Dnieper River valley at its upper course was formed in the end of OIS-6 after the territory was left by the Moscovian (Late Saalian) ice sheet. In the Early Valdai (Early Vistulian, OIS-4) epoch the ice margin was far from the valley, but during the Late Valdai (Late Vistulian, OIS-2) time valley was subject to direct influence of the ice sheet. During the Last Glacial Maximum (LGM, 20-23 ka BP (cal)) the ice margin was located in the vicinity of the upper Dnieper valley (Fig. 1.2). Upstream from Smolensk it stayed 50-70 km to north/north-west from the valley. Glacial melt waters were transported to the Dnieper valley via its right tributaries - rivers Vop', Hmost', etc. and contributed much to both water and sediment discharge of the Dnieper River. At that time the river upstream from Smolensk had wide braided channel 15-20 times as wide as the modern river. Glacial melt water input to Dnieper during LGM is estimated at 40 km³/yr [Sidorchuk et al., 2011], which is 13 times as great as recent river runoff at Smolensk. Input of glacial melt waters lasted for about 3 thousand years: since the maximum (Bologoye) stage of the Late Valdai glaciation (21.5 ka BP cal.) till the Vepsovo stage (18.5 ka BP cal.).

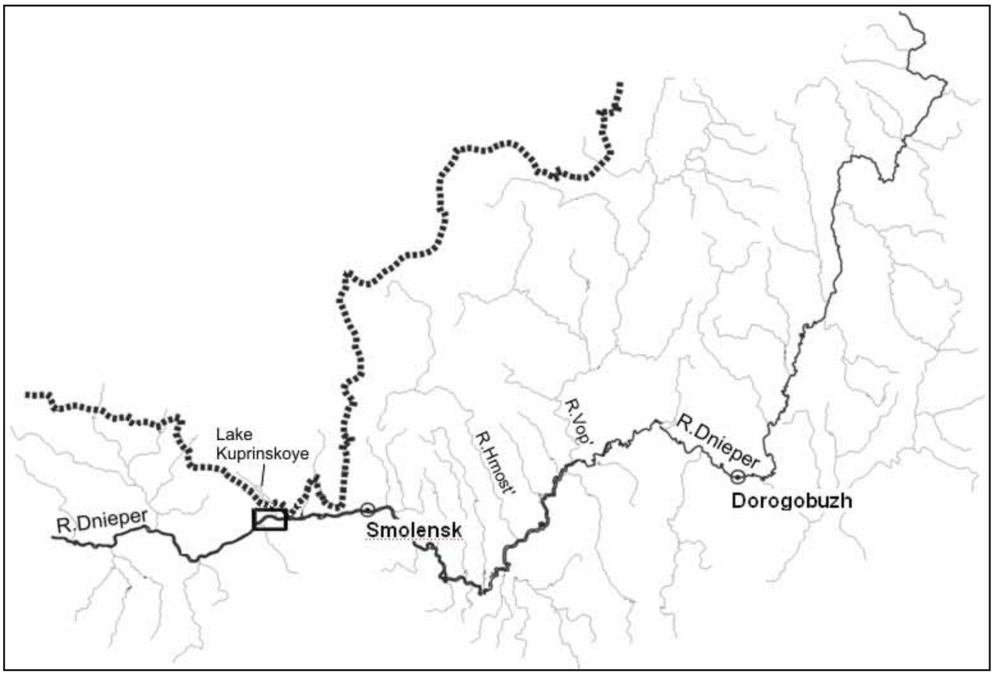

Figure 1.2. Map of the Upper Dnieper River system.
Dashed line – ice shet margin during LGM [after: Map …, 1998].
Rectangle west from Smolensk – area shown in Fig.1.3.

Several alluvial terraces are found within the valley bottom. Elevation interval 10-15 m is occupied by Late Valdai (OIS-2) terraces that are divided into two levels: 12-15 m (T1b) and 10-12 m (T1a). They are composed of sandy alluvium with no loess or sheet loam cover on the surface. Valley bottom width at the 15-m elevation level is 1.2-1.5 km of which terrace T1 occupies approximately one half (from ¼ to ¾ from place to place). Holocene floodplain has changeable width from <200 m to >700 m and usually differentiates in morphology with rather smooth Early-Mid Holocene parts and high-relief areas formed in the Late Holocene. River channel is 80-100 m at bankful stage. The channel has irregular pattern: long straight stretches alternate with short series of 2-3 meander bends with varying curvature.

Problem of erosion remnants

Characteristic features of the Upper Dnieper valley are erosion remnants with flat or gently sloping top surfaces rising to 25-35 m above the river. Usually they resemble islands in their planform, with typical length and width 1-3 km and 0.5-2 km respectively. They are usually separated from valley sides by huge fluvioglacial channels. Such forms are found in a long section of the valley: from River Vop' downstream to the Russia / Byelorussia border and in Byelorussia between Orsha and Shclow cities where they were studied by Kalicki [1995], Kalicki and San'ko [1998]. Parameters of erosion remnants and related palaeochannels are much larger than fluvial features of modern river, i.e. the modern river underfits (term by Dury, 1964) its valley. Different types of such underfitness are widely found in river valleys because of high amplitude runoff oscillations in the past. Underfitness is most often indicated by meandering palaeochannels. Specific erosion remnant – large palaeochannel morphology of the Dnieper valley gave rise to suggestion by Kalicki [1995] to distinguish “Dnieper-type underfitness”.

Age and mechanism of development of Dnieper-type erosion remnants is still unclear. Example is given by the site at Katyn-Pokrovskoye village, 10 km downstream from Gnezdovo (Fig. 1.3). Erosion remnant here is an elongated hill 30-33 m high (above the river), 3.0 km long and 1.2 km wide with long axis directed along the valley. In the south it is undercut by a large single-thread palaeochannel 400-500 m wide, which is 7-8 times as wide as the modern channel. Paleochannel is filled by 15-m thick alluvial sands with coarse-grained basal horison at the base. The erosion remnant is composed of morain (most probably, Moscovian epoch – OIS-6) covered by a 1-2-m thick cover of fine to medium sand. This cover has probably aeolian origin. The modern Dnieper River channel located north from the hill is incised into morain. Both floodplain and 15-17-m terrace have only 2-4 m of alluvium over the morain basement. These features are indicative of spillway origin of this stretch of the modern channel, but mechanism of channel jump over a 30-m hill is problematic both in this and in other examples of erosion remnants as well as remnant age. Direct influence of Late Valdai (OIS-2) ice sheet in the form of glacial damming an / or glacioisostatic crustal movements can not be universal mechanism of development of erosion remnants because they are found both in the vicinity and far away from ice boundary. Ice sheet direct influence may be taken into account only for the Katyn-Pokrovskoye site.

Large palaeochannels are most probably Late Valdai (OIS-2). If remnants had the same age and were formed due to incision of fluvioglacial flows, there must be wide sandur plain in the valley at elevations corresponding to remnant tops. No such geomorphic level exist in the valley. Late Valdai (OIS-2) terraces are only 10-15 m high and thin covers of fine to medium sand on tops of remnants can hardly be interpreted as deposits of fluvioglacial flows. These sand covers have most probably aeolian origin with large palaeochannels as sources of sand. Elevation of highest remnants corresponds to the level of 30-40-m fluvioglacial terrace (“third terrace”) formed during melting of the Moscovian ice sheet (end of OIS-6). Therefore the dissection of the valley could occur in

Late Moscovian (end if OIS-6) epoch due to incision of Moscovian fluvioglacial flows. On the other hand, the third terrace and watersheds beyond the limits of the Valdai ice sheet are covered with thin (1-2 m) cover of homogenous loams called "cover loams". Younger elements of the valley such as low terraces and floodplain are devoid of cover loams. No cover loams is also found on remnant tops which may be indirect indicator of their younger age. Irrespective of the time of incision, question is also whether the incision occurred in both branches simultaneously or the modern (Holocene) channel had been cut separately – in the latter case mechanism of channel jumping over high hills is problematic.

To summarize, initial formation of the remnants relates most probably to action of fluvioglacial flows in the end of OIS-6 when the Upper Dnieper valley began to form after the territory was released of the ice sheet. Branches of wide flow deepened to form incised braids. It is unknown whether these branches functioned continuously since the end of OIS-6 till the end of OIS-2.

Problem of ice-dam lake and river development in the Late Valdai (OIS-2) epoch

Downstream from Smolensk the LGM ice margin reached the Dnieper valley. One of discussionable questions of local geomorphology is whether the river was dammed by the glacier. According to Salov [1972], one ice tongue that moved through the valley occupied now by Lake Kuprinskoye and River Katynka (flows from the lake and tributes to Dnieper) dammed the river and forced it to shift to the south. Kvasov [1975] suggested that due to this glacial barrier a huge dammed lake was formed with the level up to190-195 m a.s.l. (30 m above the modern Dnieper at Smolensk). He proposed that water of this lake overflowed to the Volga River basin and was one of sources for the Khvalyn' transgression of the Caspian Sea. On the other hand, no geomorphic traces of this overflow exist and no lake shorelines or lacustrine deposits are known in the Dnieper valley which makes the hypothesis of high damming doubtful. Nevertheless, valley lake of lower level seems to have existed in LGM time: its sedimentological indicators were found at the Gnezdovo section of the valley.

Data from boring and examination of bank exposures at Gnezdovo show that both floodplain and low terrace alluvium is underlain by silty clays with microlamination structure. At places they contain sand both dispersed and in the form of lenses. These deposits are interpreted as sediments of a semi-closed valley lake. The base of lacustrine unit was detected at 6.0 m below the river low water level. They are underlain by alluvial or fluvioglacial coarse sands with fine gravels. The roof of lacustrine clays is variable depending on the depth of channel erosion. Maximum elevation of lacustrine clays was detected on terrace T1b: their roof was found under 7.5 m of alluvium (medium to coarse sand) at +6.5 m above the river. Initial thickness of lacustrine clays is therefore not less than 13.5 m (lower estimation).

Given high potential sedimentation rates due to high turbidity of water, total time needed for accumulation of the whole lacustrine unit must have not exceed few thousand years. As the middle of the lacustrine unit was OSL dated to 21-22 ka BP cal. (see Stop 4 in Chapter 1.3 for details), the whole period of lacustrine sedimentation probably occurred within LGM (20-23 ka BP cal.). Given that, formation of this lake may be forced by some impact of the ice sheet. Two mechanisms are possible. First, glacial damming at the Katyn-Pokrovskoye section (see Fig.1.3). The following facts are in favor of this mechanism: (a) absence of lacustrine clays at this section, (b) modern river cutting into morain deposits while 10 km upstream at the Gnezdovo section alluvial fill exists under lacustrine unit. Weak point of this hypothesis is that glacial advance across the river valley has not been proved yet by any argument other than valley morphology.

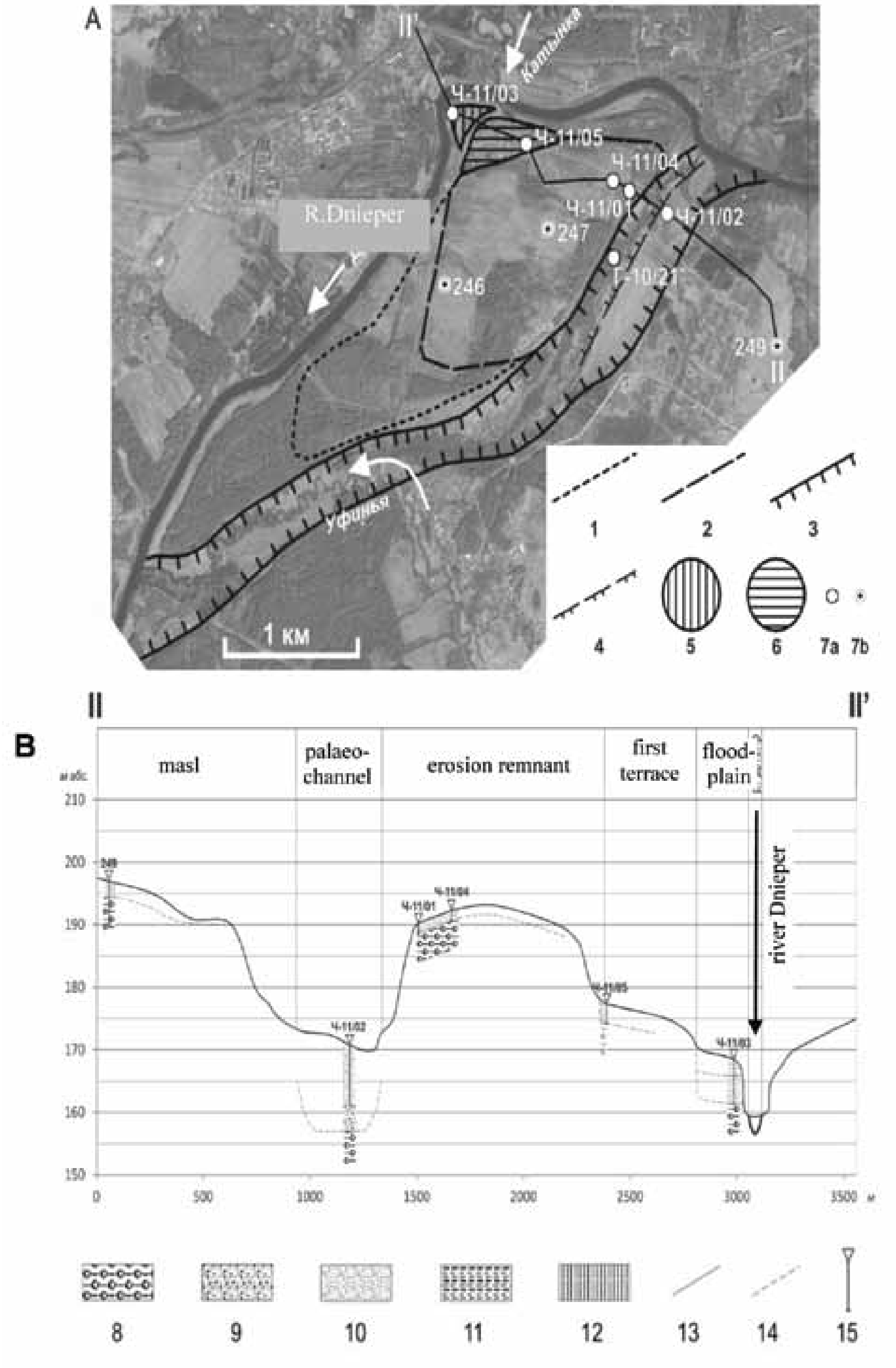

Figure 1.3. Map (A) and geological profile (B) across the erosion remnant in the Dnieper River valley at the Katyn-Pokrovskoye village (see Fig. 1.2. for location). 1 – foothill (about the 175 m contour line); 2 – edge of hill top; 3 – borders of the Late Vistulian paleochannel; 4 – borders of different levels of the palaeochannel; 5 – floodplain (8-10 m); 6 – 15-17-m terrace; 7 – cores (a – made by authors, b – Abramzon et al., 1981). Legend for profile: 9 – glacial till; 10 – coarse sand with gravel; 11 – fine and medium sand; 12 – silty sands and sandy loams; 13 – cover loam; stratigraphic boundaries: 14 – reliable, 15 – probable; 16 – cores.

Second possible mechanism is occurrence of glacioisostatic crustal movements around the edge of the Katyn glacial lobe. Local depression several tens of kilometers in diameter formed around the maximal glacial advance could promote formation of semi-closed basin within river valley. Occurrence of compensating uplift after glacial retreat may be evidenced by relative hight of large fluvioglacial palaeochannels at Katyn-Pokrovskoye section and at River Vop' 100 km upstream: in both cases palaeochannel surface lies at the same absolute height of 170-172 m a.s.l. while the modern channel falls by 7 m within this 100-km stretch. On the other hand, this hypothesis can not explain absence of lacustrine sedimentation in the centre of depression – at the Katyn-Pokrovskoye section (Fig. 1.3). Both hypotheses are favored by the fact that lacustrine clays disappear not farther than 100 km upstream, i.e. the lake was only several tens kilometers long. Probably combination of both hypotheses would explain all facts in the best way.

Both the glacial damming and erosion remnants problems will be advanced after establishing absolute chronology of large fluvioglacial palaeochannels and sand covers (OSL dates are coming soon from the GADAM Centre, Silesian University of Technology).

River development in the Holocene

During the Early and Mid Holocene the Dnieper River in the vicinity of Smolensk did not demonstrate active dynamics. Only two palaeomeanders are found at the 20-km valley stretch downstream from Smolensk (Fig. 1.4).

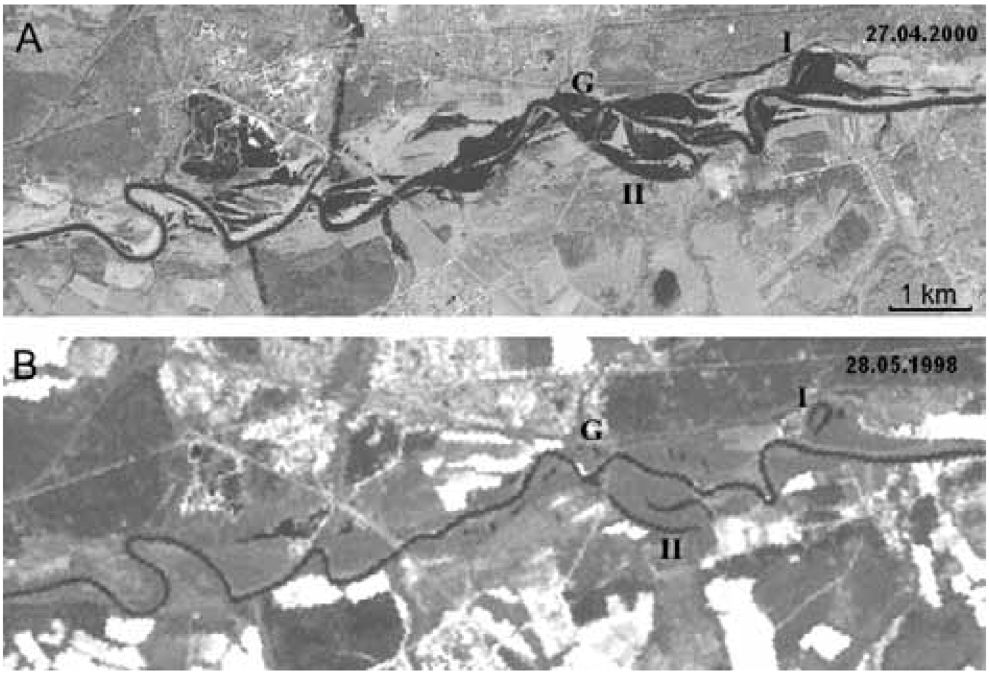

Figure 1.4. The Dnieper River valley downstream from Smolensk: A – at high water stage (spring flood), B – at low water stage. I, II – Palaeomeanders (see text). G – Gnezdovo settlement.

Palaeomeander I at the right river bank 2.5 km upstream from Gnezdovo is a loop developed since the Early Holocene and abandoned due to neck cutoff some 3.5 ka BP cal. (Fig. 1.5). Development of such sinuous channel is possible if floodplain inundation is too shallow to maintain flow velocities necessary for surface erosion and creation of a straightening channel. Relatively low channel-forming discharges during the Palaeomeander I development are indicated also by bankfull width: in the palaeochannel it is lower than in the modern channel (60-70 m versus 90-100 m).

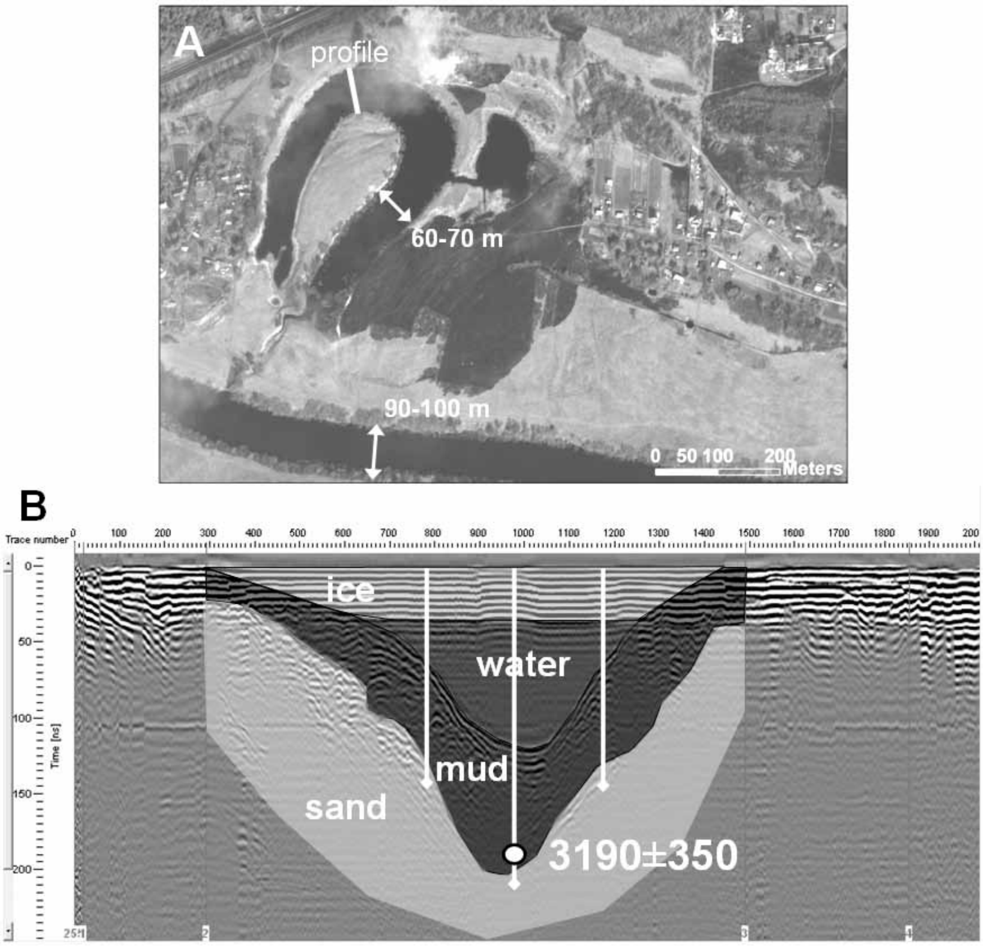

Figure 1.5. Palaeomeander I (neck cutoff): Space image (A) and GPR profile (B)

Low flood activity in the Early/Mid Holocene is indicated also by buried floodplain soils dated to the second half of the Atlantic period. One of such soils dated at 5200±130 (IGAN-3891) was found at the left bank 1.2 km upstream from the Gnezdovo site. The other Atlantic soil dated at 6540±70 (IGAN-3835) was found at the Gnezdovo site and will be shown during the field excursion (see Stop 4, section 07-03 in Chapter 1.3). These soils on the left and right bank formed on different parent materials. On the left bank these are re-deposited red colored material, extremely rich in oxalate and dithionit extractable iron oxides, on the right bank (section 07-03) these are ordinary floodplain silt loams. General processes of Atlantic soil formation are the same: lessivage (less intensive comparatively to Subatlantic buried soil), redoximorphic procceses related to periodical water stagnation mostly in eluvial part of the profiles and along biogenic channel and segregation of iron oxides, gleization of borrom horizons.

The Late Holocene was characterized by high amplitude oscillations of flood activity.

Low flood activity characteristic for Early / Mid Holocene was interrupted by extreme floods in the beginning of the Late Holocene. It is evident from chute cutoff of Palaeomeander II which developed through the most part of the Holocene (Fig. 1.6).

Dating of sedimentary fill of palaeochannel gives the time estimation of meander avulsion: >2.0 ka BP cal. More precise dating of extreme flood period will be given in the floodplain part of field excursion (see Stop 3 and Stop 4, next chapter): between 2.4-2.7 ka BP.

Low flood activity was characteristic for the next time interval between 2.0 (2.2?)-0.8 ka BP. End of this interval corresponds to the Medieval Warm Period (MWP). Low frequency of floodplain inundation promoted formation in the floodplain of well developed Albeluvisols which are typical loamy zonal soil of boreal forest ecosystems.

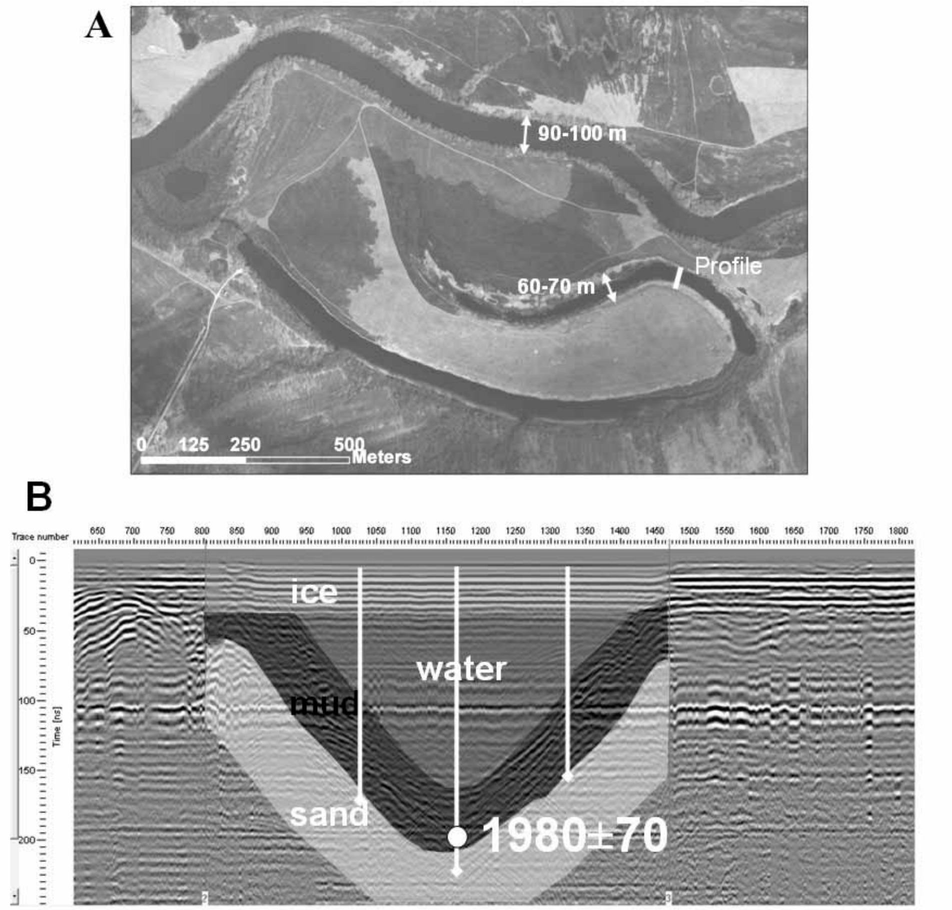

Figure 1.6. Palaeomeander II (chute cutoff): Space image (A) and GPR profile (B)

High floods, deep and frequent inundation of floodplain resumed some 800 yrs BP. Period of relatively high floods lasts since early XIIIth century till now. Within this interval, two phases of highest flood activity occurred that are detected by high sedimentation rates and increasing grainsize of overbank deposits. First phase dated to the XIV / XVth centuries boundary is visualized by clearly laminated sand layers in overbank alluvium at Gnezdovo. Second phase of highest floods occurred probably in the middle of the XVIIth century. This phase has been detected at the left bank on the floodplain segment between the modern river and Palaeomeander II (see Fig. 1.6). In 1631, during the siege of Smolensk, the military camp of Polish king Vladislav was located here. Archaeologists V. Kurmanovskiy and V. Nefiodov (personal communication) found several fortification structures of this camp (ditches, ramparts) buried under 1-1.5 m of alluvial sands. Surface of artificial structures is not reworked by pedogenic processes which evidence that the burial occurred shortly after their construction.

On the other hand, two periods may be characterized as intervals of relatively low flood activity – beginning of the XVIIth century and XXth century – nowadays. Recent situation may be illustrated by a relatively high spring flood in 2000 (Fig. 1.4 A). This flood was one of the highest in the last decades, the topmost areas of floodplain were not inundated, though clearly laminated overbank alluvium of previous centuries is found there. Some lowering of flood activity in early XVIIth and XXth centuries resulted in formation of a variety of Fluvisols wich are typical sin-sedimentary soils of regularly inundated floodplains.

Synthesis of river history during OIS-2 - OIS-1

Graph of the Dnieper River aggradation/incision during OIS-2 based on the above data is shown in Figure 1.7.

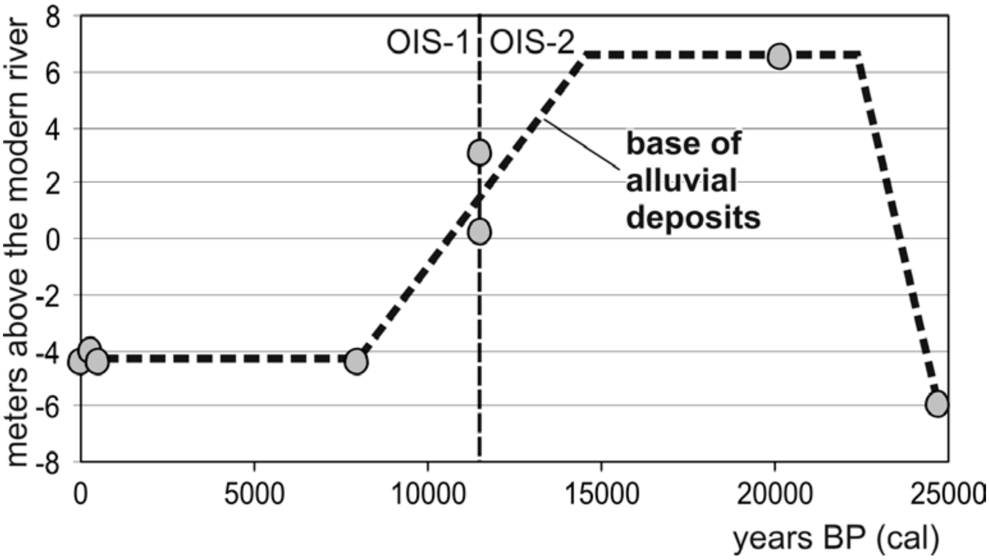

Figure 1.7. Dnieper River incision / aggradation dynamics during OIS-2 – OIS-1 epochs

The fact that lacustrine clays are underlain by alluvium and base of lacustrine infill lies deep under the modern river (6 m below low water level, 1-2 m below channel floor) indicates that prior to LGM the river was incised 1-2 m deeper than it does at present. Lacustrine / alluvial accumulation during LGM may be estimated minimum at 12-13 m as during formation of the T1b terrace (12-15-m terrace) alluvial base and its contact with lacustrine clays lied already at 6.5 m above modern river. Given that this contact is an erosion-type boundary, the above estimation of total value of deposition is minimal. During formation of the 10-12-m T1a terrace alluvial base was at about 3.5 m above the modern river, i.e. incision by about 3 m took place compared to the T1b terrace, but the channel still was 7-8 m above the modern channel (alluvial base of modern channel is 4-5 m below low water level). The T1a terrace was radiocarbon dated to the Pleistocene/Holocene boundary (see Stop 4 in Chapter 1.3 for details). Morphology of the terrace evidence that the river channel was split into multiple braids, which is responsible for low thickness of alluvial series characteristic for both T1b and T1a – 6-8 m.

River incision proceeded in the Early Holocene. Not later than by 7-8 ka BP cal. the river had incised to its present position and preserved it by present. Variations of floodplain inundation in the Mid- and Lat Holocene detected from sedimentology of overbank alluvial facies (for example, buried soils) are therefore induced by changes of hydrological regime only. Incision in the Early Holocene had in a large part proceeded due to river concentration in single channel: deepening of channel bottom by 7-8 m was followed by considerable rise of seasonal amplitude of water levels. Therefore topmost parts of the Late Holocene floodplain rise at almost the same elevation as the T1a terrace and thickness of Holocene alluvial series is 12-13 m (against 6-8 m in the Late Valdai).

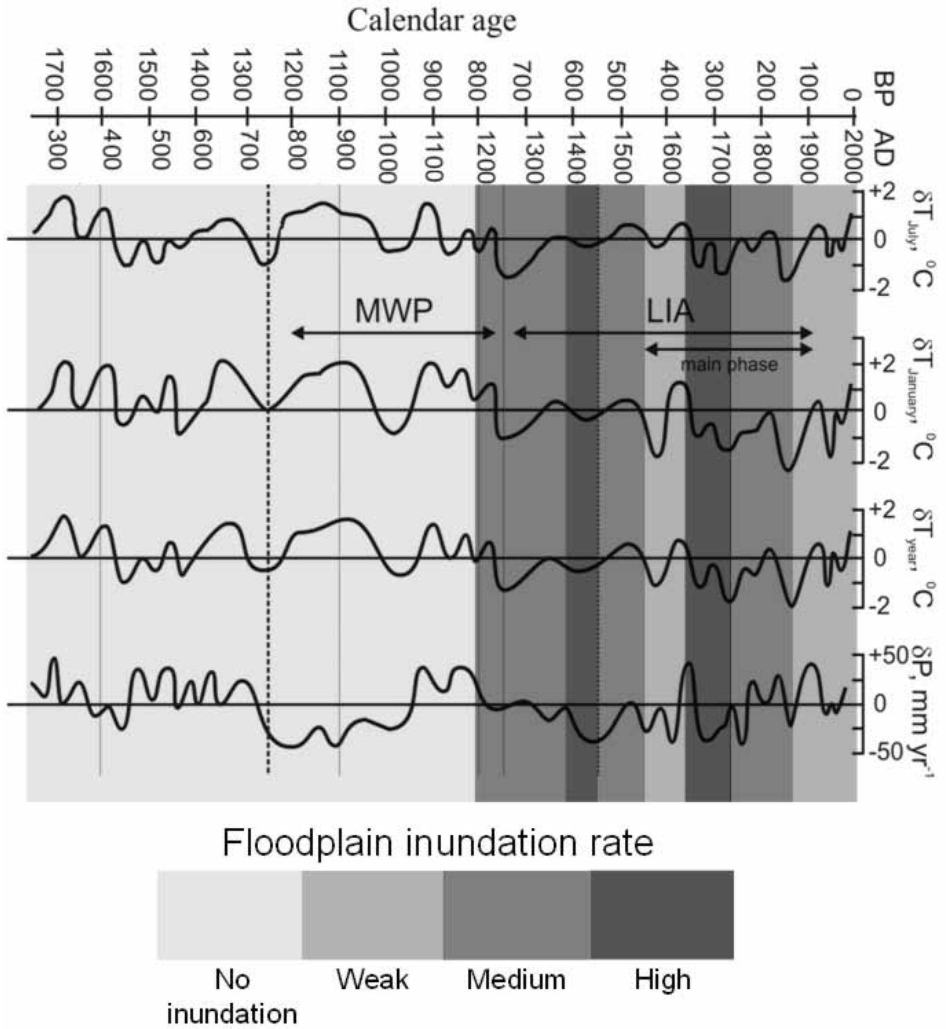

Figure 1.8. Climate change in the center of the Russian Plain in the last two millennia (after Klimanov et al., 1995) and palaeohydrology of the Dnieper River

Most reliable palaeohydrological data exist for the Late Holocene and reveal clear correlation with climate dynamics (Fig. 1.8). In general, rise of flood activity corresponds usually to climate cooling. Intervals of warming are usually marked by low floods or even interruption of floodplain inundation. For example, extreme floods at the start of the Late Holocene (avulsion of Palaeomeander II, scouring on floodplain at Gnezdovo – see Chapter 1.3) correspond to the 2.6 ka cooling event. Interruption of floodplain inundation in the first millennium AD coincides with relative warming, and its final phase – with MWP. Floodplain inundation resumed together with beginning of LIA. The XVIIth century most active flooding corresponds to the Maunder minimum of Solar activity and recent lowering of inundation rates are related to pass to modern warm epoch after the finish of LIA. Such kind of correspondence follows from the Dnieper type of hydrological regime typical for rivers in the centre of the Russian Plain. Highest floods are related to spring snowmelt. Spring flood runs usually between 50-70 % of annual runoff. During cooling climate phases duration and severity of winters rise which results in higher storage of snow and higher spring floods. In opposite, during warm epochs snow storage drops and spring floods become weak. This is clearly observed during the last 10-15 years of global warming.

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CHAPTER 1.3.
GEOARCHAEOLOGY OF THE UPPER DNIEPER RIVER VALLEY AT GNEZDOVO: FIELD EXCURSION

The Gnezdovo archaeological complex is located at the Gnezdovo village 10 km west from the city of Smolensk ($54^0$46.6'N $31^0$52.3'E). Territory of archaeological monument occupies different geomorphic elements of the Dnieper River valley.

Stop 1. The "Bolshoj Sizovsky mound"

The Central group of mounds occupied most of the slope on the right bank of the river Svinets, and it spread nearly to the edge of the first terrace terraced above the flood plain. The mounds consist of sandy clay and sand, sometimes containing fine gravel. These mounds were very badly damaged during the railway construction in the XIXth and the beginning of the XXth centuries. Most are 1.0-1.2 m high but it is here that we find the largest barrows. Two large mounds more than 6 m high have been preserved between two old quarries. These mounds were excavated and found to contain a rich pair of Scandinavian cremations dated to the middle – second half of the Xth century. One of these cremations included a unique sword with a handle manufactured by a master from the island of Gotland. The "Bolshoj Sizovsky mound" was partly excavated at the end of the XIXth century by Vladimir Sizov; it is 9 m high and has a diameter of about 40 m. Two pyres at the base of the barrow included the following finds: sword, helmet, hauberk, two shields, spear-head, a broken Byzantine dish with an image of the fantasy creature Senmurv (Simurgh), fragments of a richly decorated horse harness, silver mounts of a drinking horn, gaming pieces, an Arab silver coin from the beginning of the Xth century, carnelian and glass beads and many other objects. Several small barrows surrounding this large mound also contained cremation burials but were accompanied by poorer assemblages.

In the course of the 1976 excavations near the Bolshoj Sizovsky mound, several chamber graves were discovered which are dated not earlier than the second half of the Xth century.

Stop 2. Forest ("Lesnaya") group of mounds

The Lesnaya mound group occupies the southern part of the slope, a section of the terrace above the flood plain; some barrows are found at the base of the terrace and on the Dnepr flood plain. Some mounds located along the edge of the terrace were separated from the main group by the railway.

The burial mounds are usually found in compact groups. They are up to 1.5 m high but several barrows of the Lesnaya group reach 2.0-2.5 m. The barrows consist of pale yellow sandy clay and sand. It had been thought that the site had to be "cleansed" before mound building by setting fire to the grass or burning some straw or brushwood. This was the common explanation for a 5-10 cm thick layer of mottled pale grey sandy clay under the mounds. However, recent studies by a soil scientist from Moscow State University showed that this layer is made up of buried sod and cannot be a product of ritual burning. The majority of mounds contained cremations. Usually a dead body had been burned at the place of burial; the cremated remains and objects which had survived the fire were collected into urns which were similar to ordinary pottery. As a rule, a mound covered a single burial, but sometimes there were double burials of a man and a woman, or a woman with a child. Many burials included remains of horses and dogs which had served as sacrificial animals.

The oldest mounds of the Lesnaya group are dated to the first quarter of the Xth century. One of the most interesting mounds (№ 13) was excavated in 1949. It had been erected over a pyre where a Scandinavian warrior and two women had been cremated. The rich and distinctive assemblage included: a Carolingian sword, an iron necklet, Arab silver coins, carnelian and crystal beads, silver temple-rings, an amphora and a Byzantine pitcher. The amphora had been ritually broken during the funeral; one of fragments had a Slavonic inscription which read “Goroun”. Presumably this was the name of the amphora owner. The funeral conformed to Scandinavian rite of cremation, and it was for a member of the Gnezdovo elite.

Stop 3. Hillfort of the Gnezdovo settlement and overview of the Dnieper valley

Most of the central settlement occupies the first terrace above the flood plain on both banks of the river Svinets, and part of it lies on the Dnepr flood plain. The earlier buildings are found in the promontory part of the terrace on the right and left banks of the river Svinets. The early settlement was probably not fortified. The Central hillfort occupies a promontory of the first terrace above the flood plain on the left bank of the river Svinets. The open settlement is located on the terrace to the west and to the east and on the adjacent part of the flood plain to the south from it. The ditch which encloses the defended area to the east of the settlement is distinctly marked, as is a group of ramparts along its northern and part of its eastern sides. The hillfort encloses an area of 1 hectare (2.5 acres), and the total area of the central settlement is about 30 hectares (75 acres).

The Central hillfort was constructed not later than at the second third of the 10th century. The first defensive works included enhancing the terrace slope facing the river Dnepr; the earliest rampart (2-2.5 m high) and its ditch sharply separated the area of the hillfort from the settlement site. A timber wall was built at the edge of the hillfort area. The excavations revealed burnt parts of the wooden construction around the hillfort perimeter, suggesting a rebuilding of the defences at the end of the Xth century after the previous construction had been destroyed. Today the rampart is about 5 m high, its base is 17 m wide; the ditch has the depth of 4 m and a width of 18 m.

Selected archaeological finds from the hillfort area are shown on Figure 1.9.

The hillfort is a good view point to observe the *geomorphic structure of the Dnieper valley*.

Dnieper River basin area at Smolensk is 14,100 km^2, the Dnieper River mean annual discharge – 97 m^3/s (3.1 km^3/yr), mean maximum discharge – 1990 m^3/s. Hydrological regime of the Dnieper is characteristic for most rivers of central East-European Plain with dominant snowmelt feeding. During spring flood water levels rise 7-8 m above summer typically; maximum annual amplitude of water levels is around 12 m. Runoff during two months of spring flood (March-May) makes 50-60 % of annual runoff. In summer, especially July, levels are minimal during the ice-free season. In autumn (September-November) low rainfed floods may occur. At Smolensk and adjacent lower reach of the river floodplain is 0.7-1.0 km wide. River channel is 50-70 m wide in low water season, bankfull width is 80-100 m. Bed sediment is medium to coarse sand. Downstream from Smolensk channel pattern is generally straight with irregular meanders.

Ancient settlement occupies the right-bank floodplain segment and low river terrace (Fig. 1.10). The low terrace (“first terrace”, T1) is represented by two sub-levels:

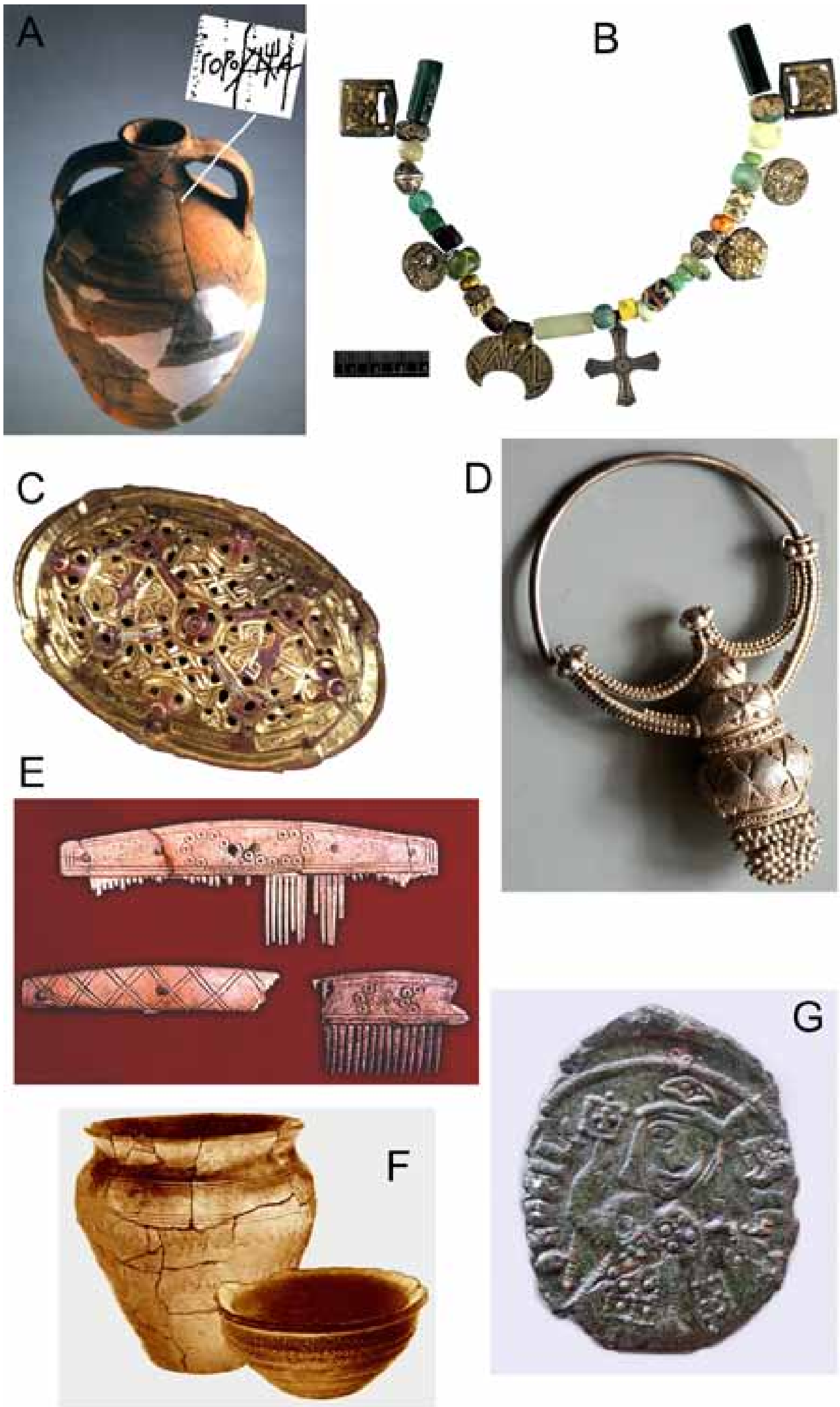


Figure Pu-1 – 1.9. Selected finds from the hillfort area
A – large earthenware pot; B – necklace; C – Scandinavian women fibula;
D –Slavish temporal ring; E – horny combs; F – vessels; G – Byzantine coin.

10-12 m (T1a) and 12-14 m (T1b). The hillfort is located on terrace T1b, other parts of the settlement spread over adjacent areas of T1a and floodplain. There are two floodplain units of different age and morphology (Fp1, Fp2 on Fig. 1.10 B) that are divided by a series of high levees (L on Fig. 1.10 B). The younger floodplain Fp1 has contrasting levee-hollow morphology made during meander shift at its inner bank (Fig. 1.11 a). Area occupied by cultural layer is limited to the older generation of the floodplain Fp2 (Fig. 1.11 b). Morphology of the older floodplain is unusual. It is characterized by smooth topography but high total relief of >4 m. High levee transverse to the general direction of the river channel divides two depressions occupied by small lakes. Elevation difference between lake levels is 2.5 m, between lake bottoms – 4 m. Such features evidence that the depressions are rather isolated pits than parts of a single abandoned palaeochannel.

Main stages of the floodplain history.

1. Formation of the older floodplain (FP2).

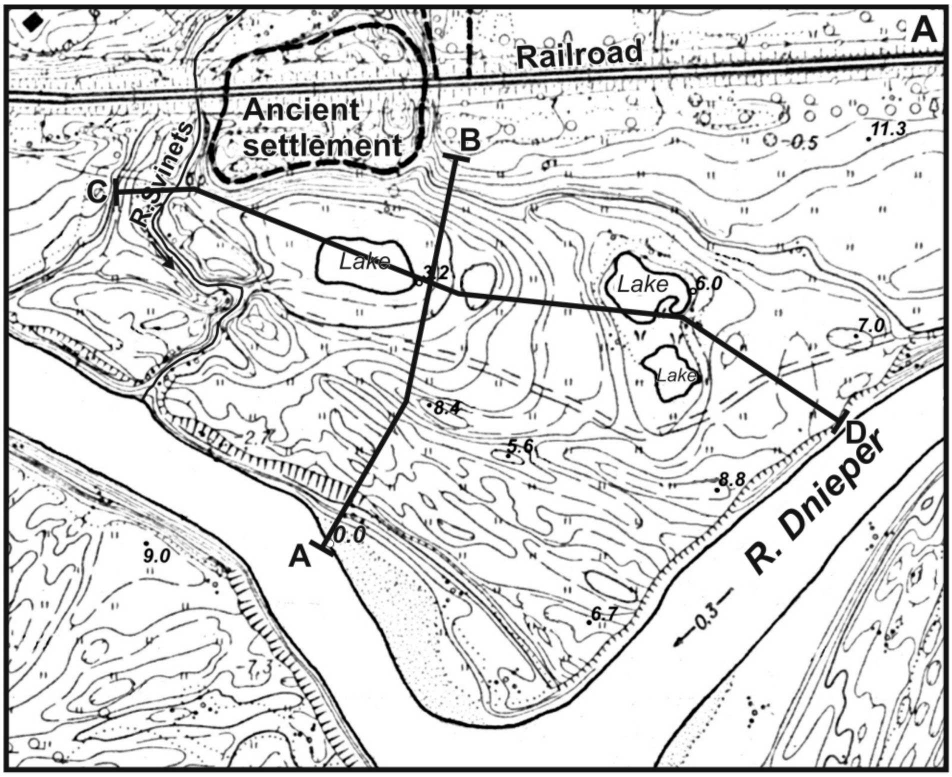
In the Early-Mid Holocene, the river had an irregularly meandering channel with low rates of bank erosion. Overbank fines accumulated on the floodplain and smoothed it. In the interval 6.5-7.5 cal ka BP sedimentation stopped probably due to decrease of flood levels, a soil with signs of zonal process of textural differentiation developed (now found buried within the overbank alluvium).

At the start of the Late Holocene a series of extreme floods concentrated probably within a short time interval led to major channel and floodplain transformation. Narrowing of the floodplain at the Gnezdovo site might have led to additional increase of flow velocities above inundated floodplain. Distinct festoons of terrace edge evidence that during the floodplain formation, the terrace was subject to undercutting by vortex flows with variable horizontal dimensions. Given that, as well as rounded outlines of floodplain depressions and transverse levee existence, the following model of floodplain formation was developed (Fig. 1.12). Deep inundation and stimulated flow macroturbulence and formation of whirlpools of different diameter. Whirlpool action produced holes 20-100 m in diameter; of which the largest is the Bezdonka Lake depression (Fig. 1.12 A). Erosion capacity of flood flows was promoted by low resistance of thin sands that make up the base of the floodplain. The eroded alluvium was partly washed out and partly accumulated at the edge of the vortex zone and formed the transverse levee between the two lake depressions. This is illustrated by scales-like bedding of alluvium visible on GPR profiles across the levee (Fig. 1.12 B). Big portion of floodplain was reworked. Residuals of Early-Mid-Holocene floodplain can be recognized by buried Mid-Holocene forest-type soil formed on fine overbank sediments.

Absolute dating of this extreme event was made by radiocarbon method. We used three dates from sediments associated with the extreme erosion of the floodplain or accumulated shortly after it. Combination of dates gives a wide interval of time with the core at 2.3-2.5 cal ka BP (Fig. 1.13). Given that the sampled sediments dates rather post-date the event, it may be associated with the 2.6-ka climatic event – climate cooling detected by isotopic composition of Greenland ice cores.

2. Break in floodplain sedimentation due to lowering of flood levels.

According to [Bronnikova et al., 2003] inundation of the floodplain had been broken after 2.4 ka BP (uncal); [Alexandrovskiy et al., 2005] refer this event to similar time: 3rd quarter of the 1st millennium BC. This stage had lasted more than 1000 years. Albeluvisols – zonal forest soils had formed on high topographical elements evidencing absence or extreme rareness of inundation. At the end of the stage, between late IXth – early XIth c. AD, the soil was disturbed at places by human impact. Occupation deposits of the Gnezdovo settlement have accumulated. In terms of World Reference Base of Soil Recourses original Albeluvisols were partly displaced by their Technic, Anthric varieties or by a variety of Technosols. Mapping of the occupation deposit (cultural layer) distribution exhibit its occurrence on the highest elements of the floodplain (Fig. 1.14).



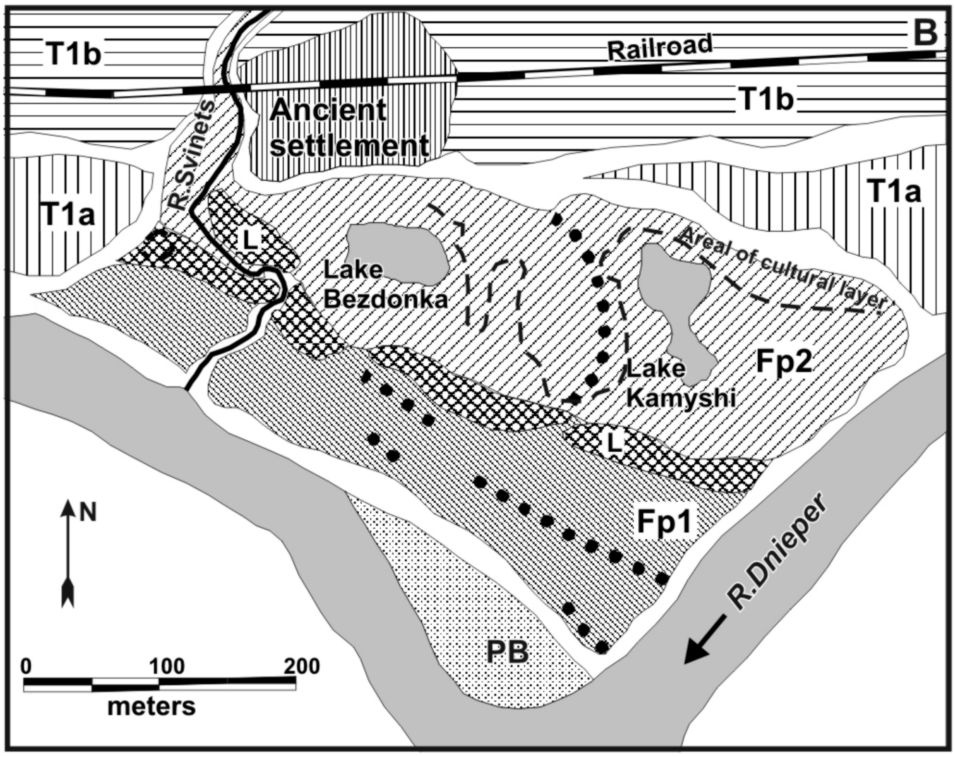


Figure P1 - 1.10. Topographic (A) and geomorphic (B) maps of the key site. Height above the river low water level. Contour interval 1 m. T1a, T1b – levels of the low ("first) terrace (10-12 m and 12-15 m respectively); FP1, FP2 – floodplain of different age (last millennium and Early-Mid-Holocene respectively); L – large ancient levees; dotted lines are young levees; PB – modern point bars.

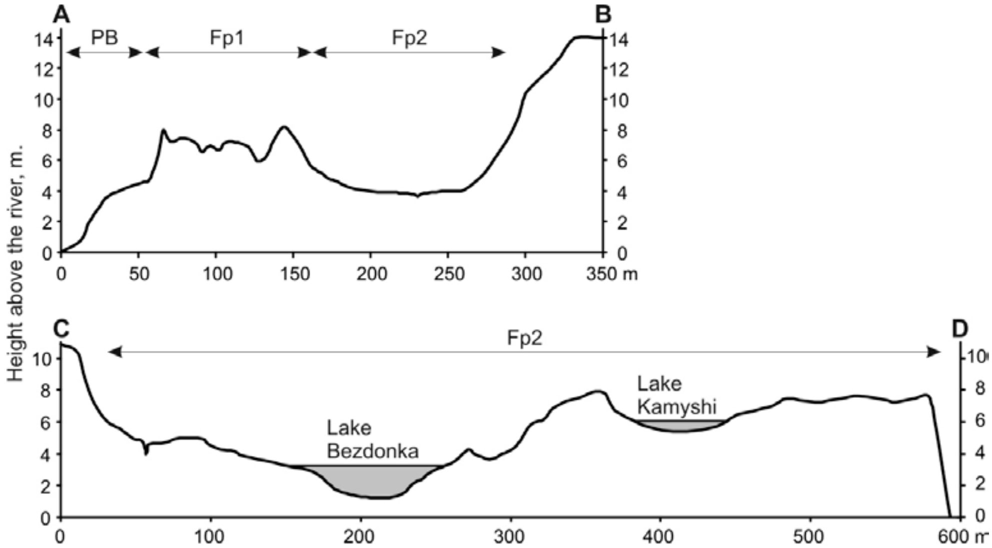


Figure.P2 – 1.11. Topographic section across (AB) and along (CD) the key floodplain area. For location see Fig.1.9B.

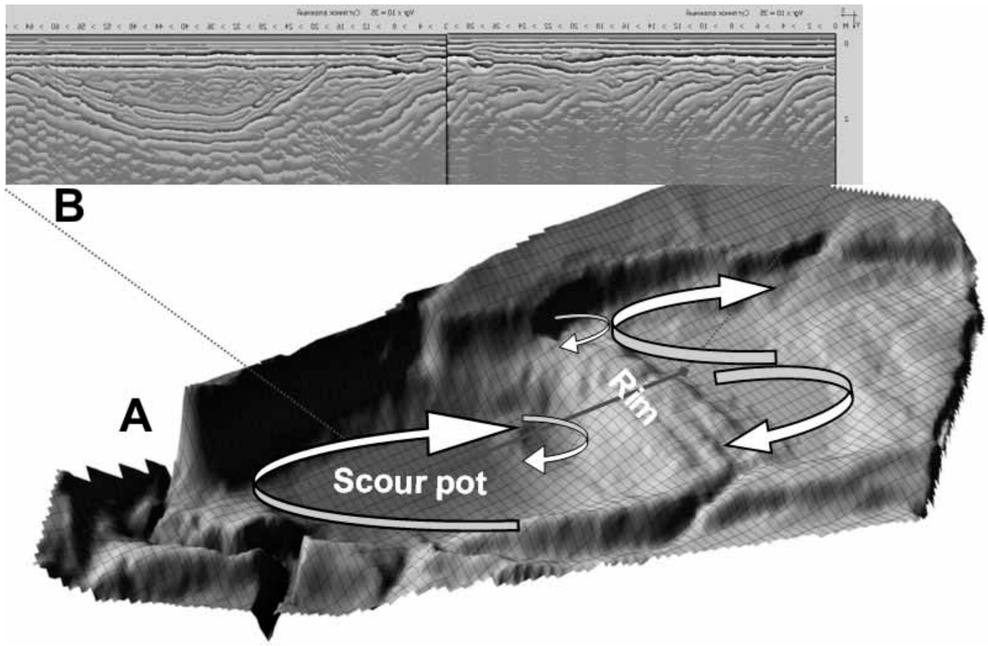


Figure P3 – 1.12. Model of floodplain formation during extreme flood(s).
A – scour pots made by a hierarchy of vortexes; B – GPR profile showing mechanism of the transverse ridge formation due to upstream sediment transport by large vortex.

Reasons for the break of floodplain inundation in Early Medieval times may be found in climatic changes. The Dnieper River hydrological regime is strongly dependant on winter snow storage. During the Medieval Climatic Optimum (MCO) in VIII-XI centuries AD warm and short winters should have resulted in relatively little snow storage and small spring flood discharges and low water levels. The same phenomenon is detected in regional scale: well developed floodplain soils buried around 1000 years ago are found in other river basins – middle Dnieper, Don, middle Volga [Butakov et al., 2000; Alexandrovskiy, 2004; Sycheva, 2003].

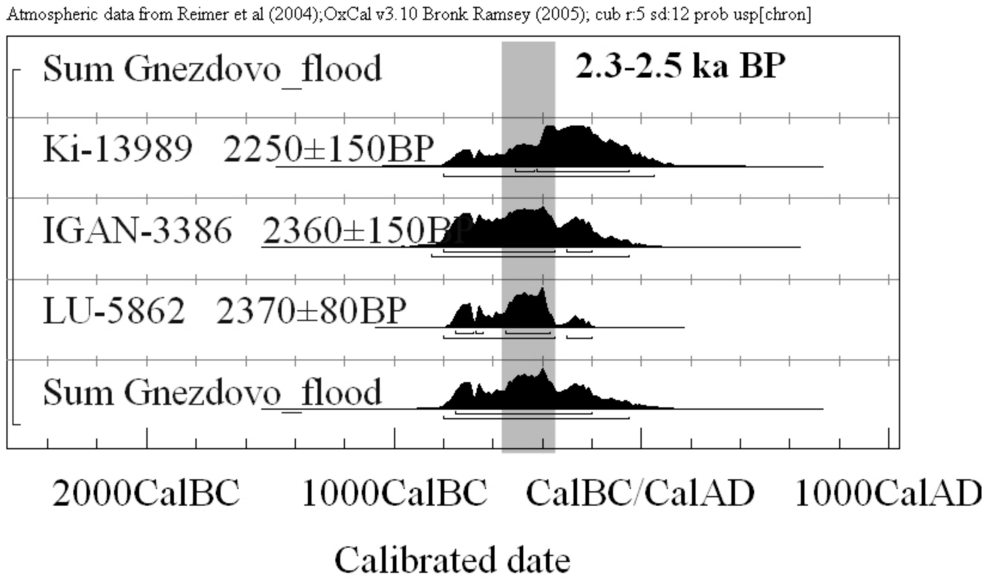


Figure P4 – 1.13. Dating the extreme flood(s).

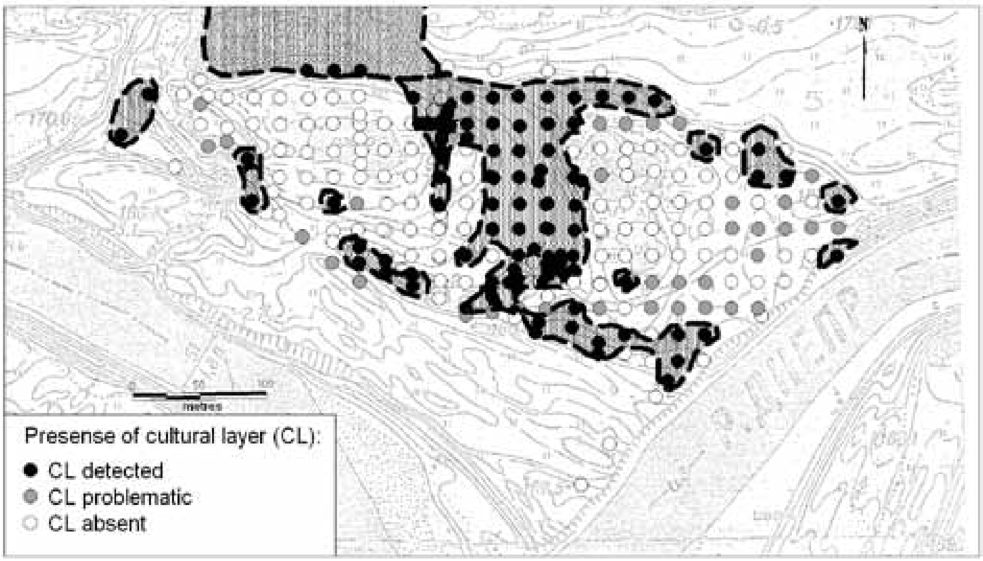


Figure P5 – 1.14. Map of cultural layer distribution over the floodplain.

<u>3. Burial of cultural layer and formation of the younger floodplain generation (FP1).</u>

Good preservation of artifacts on FP2 favors supposition that floodplain inundation had resumed soon after the cultural layer formation. Absolute dating of sediments that bury cultural layer shows that inundation resumed around the XIIIth century AD.

At Gnezdovo time, the right bank of river channel was located at the modern FP2 / FP1 boundary. Initially there was a sand slope from the smooth floodplain surface down to the river (occurrence of cultural layer under the levee deposits). Already during the settlement functioning levees began to form at the edge of FP2 (occurrence of Early Medieval artifacts within the levee deposits in the vicinity of the Svinets River tributary). Rise of floods resulted in activation of both edge levee accretion and channel bank erosion. Southward channel shift began with consequent formation of young floodplain with high-relief levee topography at the right bank. Levees mark crests of point bars that grew at the right channel bank and successively joined the floodplain. Process of floodplain side accretion and levee formation is illustrated by morphology of the modern point bar. Flood rising seems to have not initiated channel incision: the Holocene alluvial base has about the same level both at older and at younger floodplain segments.

Stop 4. Geology, geomorphology and archaeology of the Dnieper River floodplain.

Point 4.1. Modern point-bar and the last millennium floodplain.

From the modern point bar section of the 10-m terrace at the left bank may be observed (Fig. 1.15). The upper 6.5 m of the section are represented by full alluvial sequence: fine to medium sands interbedded with silts and loams with coarse sand with gravel at the base (lower 0.7 m). At depth 4.0-4.3 m alluvium is radiocarbon dated at 10.120±70 (GIN-14370). This alluvium was deposited by a braided channel that left characteristic morphology of the terrace surface. Channel braiding may be responsible for relatively little thickness of alluvium which is two times as less as that of the Holocene floodplain. Alluvial foot at 4 m above the river indicates deep river incision that must have occurred after to terrace formation. The base of terrace section is composed of firm clays with thin lamination and lenses of fine sand. OSL date at depth 9.4 m is 21.4±2.8 ka (GdTL-1238). These deposits accumulated in the open lake that was probably formed as a result of ice sheet impact over the valley (glacial damming or glacio-isostatic subsidence).

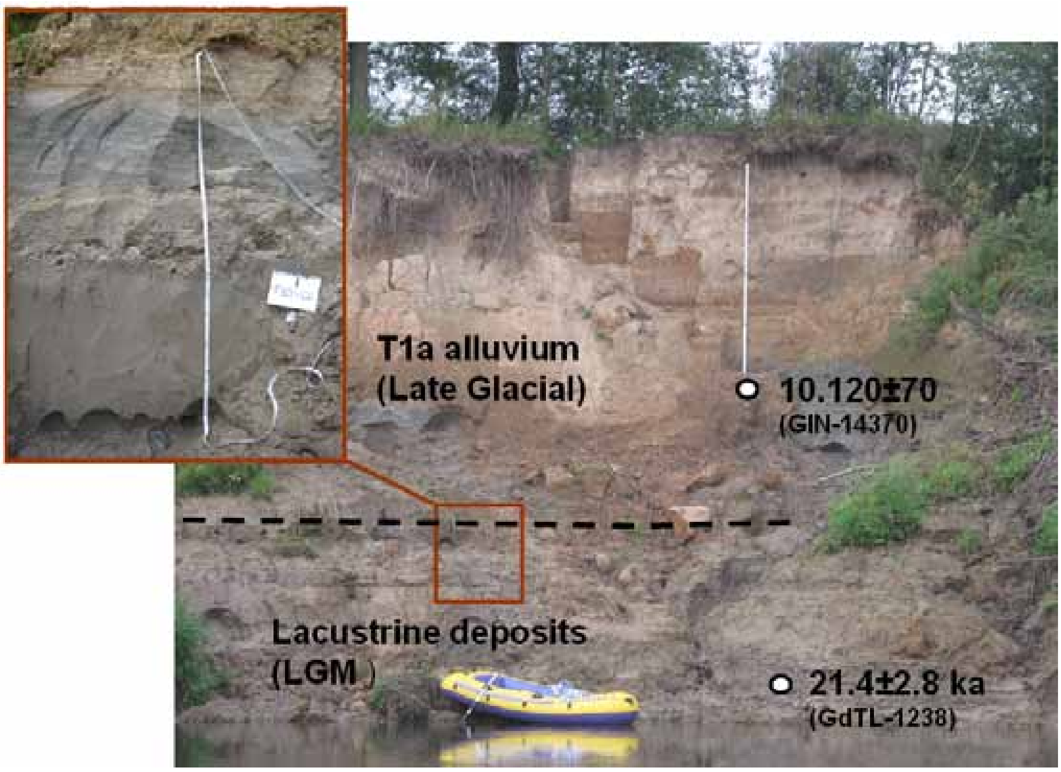


Figure P6 – 1.15. 10-m terrace at the left bank.

On the l0-m terrace the so-called left-bank group of mounds exists. The problem associated with this mound group is absence of any traces of a nearby settlement (it is doubtful that the Gnezdovo dwellers got across the river to bury their dead). Possible explanation is destruction of the left-bank settlement due to undercutting of the left bank in the last millennium that may have reached 100-200 m.

Lateral and downstream growing of the modern point bar evident from GPR profiles (Fig. 1.16) serve a model of the younger floodplain (FP1) development. We cross this floodplain generation on the way to point 3.2. The path follows along the eroded edge of the floodplain (the inner bank in the upstream part of channel bend). Lateral erosion rate in the last 40 years is 0.3-0.5 m/yr on average (10-20 m bank retreat since 1970).

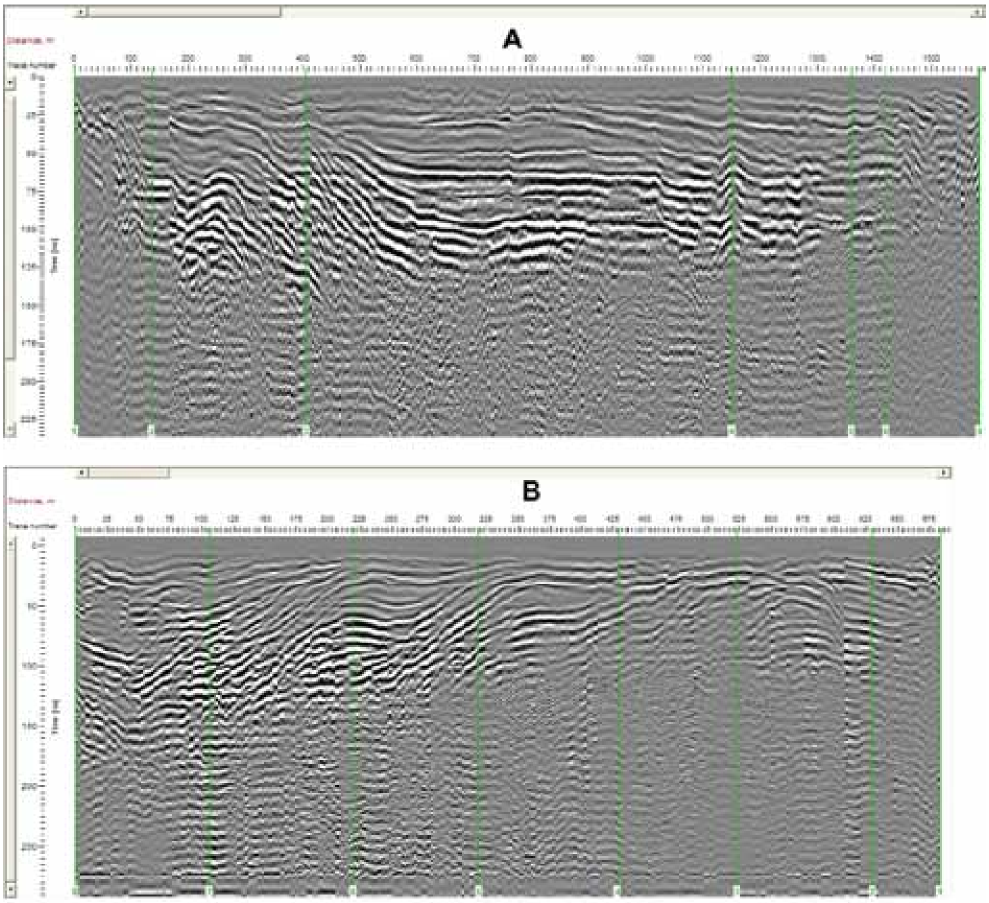


Figure P8 – 1.16. GPR profiles along (A) and across (B) the point bar showing its growing mechanism.

Point 4.2. Remnant of the Early Holocene floodplain.

Section 07-03 is located in the older floodplain generation (Fp2) on the main levee that divides Fp1 and Fp2. It is one of the oldest floodplain generations at the site. The section contains three major lithological units and four soil profiles including the contemporary one. Soil profiles are partly overlapped: pedofeatures of younger soils enter the older profiles. That complicates interpreting of changes in pedogenesis and its environment. Lithostratigraphy of the section is as follow. The lower, oldest unit is silt loam at the depth of 173 – 340 cm. The fraction 0,05-0,01 mm dominates in this unit in spite of a considerable variations in its content (Fig. 1.17 a). In some layers it is competitive with the fraction 0,25-0,05 mm. The next unit 45-173 cm is composed of sandy loams with prevailing fraction 0,25-0,05 mm. The uppermost unit (0-45 cm) is finely stratified loamy sands. The same fraction 0,25-0,05 mm prevails here, fraction 1-0,25 mm appear in the unit. A curve of organic carbon distribution has a saw-like character and do not drop lower than 0,2 % (Fig. 1.17 b) meeting the criteria of WRB for

Fluvic material. The content of organic carbon clearly rises in Ab horizons of three buried soils described in the section.

The upper limits of the buried soils are 253, 173 and 105 cm. Lower buried soil was dates by humus at 6540±70 (IGAN-3835). Other soils haven't been dated but basing on their stratigraphic position and morphology in correlation with dated sections these soils possibly were formed approximately between 2200 and 800 years BP (the second one[1]), and in the time span 600-800 BP (see radiocarbon, OSL and archaeological dates of correlative layers below).

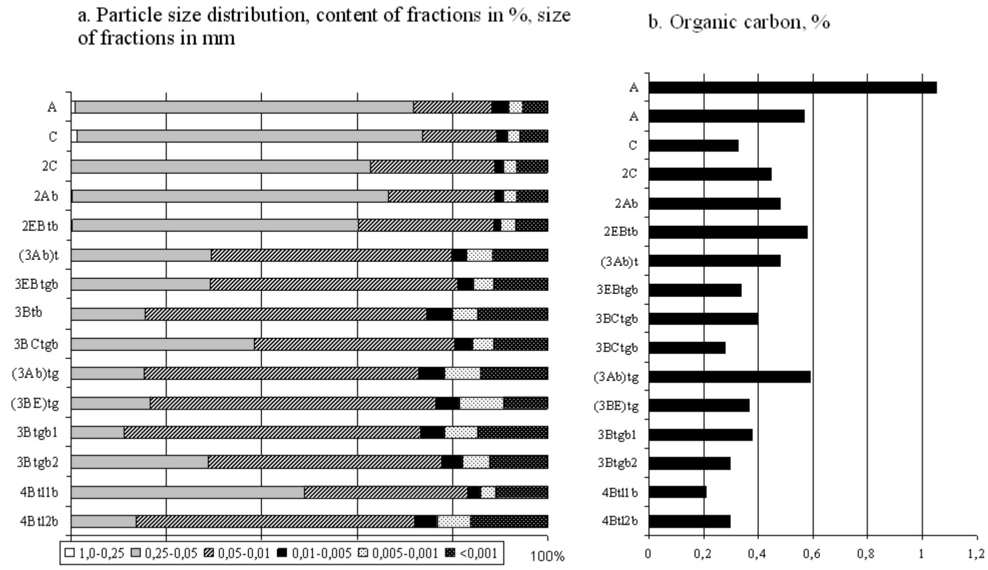


Figure Br10 – 1.17 Section 07-03: analytical features.
a – Particle size distribution; b – content of organic carbon.

Textural pedofeatures (coatings, infillings, intercalations composed of translocated silicate sand, silt, clay, with admixtures of humus and iron oxides, or unsorted silicate material) is related to zonal processes of intrasoil migration of silicate material (lessivage). In soils of floodplains these pedofeatures are diagnostic for more or less long-term interruption of sedimentation related to seasonal inundation. These pedofeatures first appear in the section 07-03 from the depth of 173 cm (in the second Ab horizon) (Table 1). At this depth they are very faint and few and definitely related to the youngest buried soil. That means these pedofeatures are epigenetic for the second buried soil (formed after it was buried, in the next phase of pedogenesis). The phase of illuviation referred to the upper buried soil was obviously incipient and very short, so that related to it illuvial maximum (recorded as a maximum of clay fraction and micromorphologically registered maximum of textural pedofeatures) is combined with the next one of the second buried soil. Double-maxima distribution of textural pedofeatures (Table 1) is in good correspondence both with field morphology of the profiles and distribution of the clay fraction <1 mm (Fig. 1.17 a).

Occurrence of textural pedofeatures starting from the first buried profile evident for more or less prolonged drops of sedimentation rates and even hiatuses in floodplain

[1] We will call it below "Gnezdovo soil", because early medieval habitation activities in the floodplain part of Gnezdovo settlement are related to this soil). This is the most widely spread and well developed buried soil in the floodplain soil-sedimentary sequences of the Upper Dnieper valley.

sedimentation. The last ones gave the way to zonal pedogenic processes in the mid-Holocene time, 2200-800 BP and 800-600 BP spans. Surface, contemporary soil, in the opposite, is typically sin-sedimentary Fluvisol without any signs of zonal pedogenesis.

The longest period of ceased floodplain sedimentation and active textural differentiation of fluvial material within the last 6500 years is referred to the Gnezdovo soil. In this section Gnezdovo soil has no signs of any human impact as far as it is located behind the borders of Gnezdovo settlement. This soil has well developed profile of Albeluvisol – typical soil of boreal ecosystems formed on loamy material. It has all attributes of Albeluvisols. The profile includes Albic horizon which is bleached and zonally impoverished in clay (Fig. 1.18 c). At the same time neighboring zones of it are often enriched in lluvial clay related to the next buried soil. In this horizon certain signs of intra-soil weathering such as transformations of biotite are observed (Fig. 1.18 a). Albic horizon is underlain by a series of Argic ones with numerous and variable textural pedofeatures. Argic and transitional BC horizon contain redoximorophic features: iron impoverished zones and iron-manganese nodules related to seasonal water logging.

All of three buried soils have got more or less developed profiles of textural pedofeatures. In the section 07-03 following morpho-substantial classes were described during microscopying (Table 1): 1. clayey, Fe-oxides and / or humus containing, low anisotropic (Fig. 1.18 d, c, f); 2. sandy-silty, well sorted (Fig. 1.18 d, e); 5. clayey, with bright self and interference colors, sharp strait or wavy extinction (Fig. 1.18 b, e); 6. clayey, pale, impoverished by iron oxides. These classes often are combined in compound coatings (Fig. 1.18 d, e). Together with coatings and infillings textural pedofeatures occur also in numerous intercalations, which are believed to be related to ground waters [Fedoroff, Courty, 2012]. Generally, the most widely spread are classes 1 and 6. Fe-clay or Fe-oxide coatings are combined with Fe-impoverished (often as an alternation of layers within one compound coating). This is characteristic for at least seasonal water stagnation in the eluvial part of the profile [Gerasimova et.al, 1989]. For Gnezdovo soil along with Fe-rich and Fe-impoverished textural pedofeatures clay coatings and infillings with bright yellowish-brown self- and interference colors are typical (class 5). This kind of coatings is formed only in well drained conditions. They are result of so called primary illuviation [Fedoroff, 1972], when iron oxides and clay migrate and accumulate together. It should be stressed that this class of textural pedofeatures is an essential attribute of Gnerzdovo soil in floodplain soil-sedimentary sequences of the Upper Dnieper region. These textural pedofeatures could be used as a sort of stratigraphic marker.

Contradictory co-existence within one profile of classes 1, 6 characteristic for poor drained conditions in eluvial part, morphologically different intercalations belived to be related with ground water influence and the class 5 typical for perfectly drained soils is actually a record of successive processes of soil evolution from a well drained phase to a phase of drainage deterioration resulted both from a rise of ground water and seasonal water logging due to decreased water permeability of Argic horizon. Relations of textural and reoximorphic features are important in connection with time sequence of pedogenic processes. Fragments of brightly colored coatings are often found within Fe-nodules, at the same time Fe-enriched and Fe-impoverished layered coatings are described above nodules (Fig. 1.18 f). That supports the conclusion on deterioration of drainage in the end of Gnezdovo soil development (before it was buried.

The interpreting of Mid-Holocene soil is not very reliable due to its strong overlapping with the Gnezdovo soil. This Mid-Holocene soil is characterized by relatively high biological activity in its top horizon and comparatively abundant redoximirphic features. Taking in account clear and logical within-the-profile depth distribution of redoximorphic features (Table 1): increasing their number with depth, increasing a contrast between an oxidation and reduction zones and appearance of oxidation zones along ped surfaces in lower B horizon, it is possible to conclude sin-genetic (life-time) short-term reductimorphic conditions in the upper part of the profile and at least seasonal influence of ground waters on the bottom part of the profile.

Table 1. Section 07-03, textural and redoximorphic features

Horizon	Textural pedofeatures							Redoximorpic features: relative abundance
	Classes according the composition and morphology (see below the table)						Relative abundance	
	1	2	3	4	5	6		
A	–	–	–	–	–	–	–	–
C	–	–	–	–	–	–	–	–
2C	–	–	–	–	–	–	–	–
2Ab	–	–	–	–	–	–	–	–
2EBtb	–	–	–	–	–	–	singular	–
(3Ab)t	+	–	–	–	–	–	+	–
3EBtgb	+	+	–	–	–	–	+	–
3Btgb	+	+	–	–	+	+	++	+
3BCtgb	+	+	–	–	+	+	+++	++
(3Ab)tg	+	+	–	–	+	+	+++	+++
(3BE)tg	+	+	–	–	–	+	++	+
3Btgb1	+	+	–	–	+	+	+++	+
3Btgb2	+	+	–	–	–	+	+++	++
4Btl1b	+	+	–	–	+	+	+++	+
4Btl2b	+	+	–	–	+	+	+++	+++

Classes of textural pedofeatures according their composition and morphology (+ occur, – do not occur): 1 – Clay, Fe-oxides and/or humus containing, low anisotropic; 2 – Sandy-silty, well sorted; 3 – Silt and silt clay, unsorted, with admixture of sand, organic (humus impregnation or/and charcoal dust); 4 – Clay with admixture of organic, grayish colour in polarized light, low anisotropic up to isotropic, diffuse or flecked extinction; 5 – Clay, with bright self and interference colors, sharp strait or wavy extinction; 6 – Clay, pale or nearly colorless, impoverished by iron oxides.
Relative abundance is estimated in following classes: – no, + few, ++ common, +++ abundant

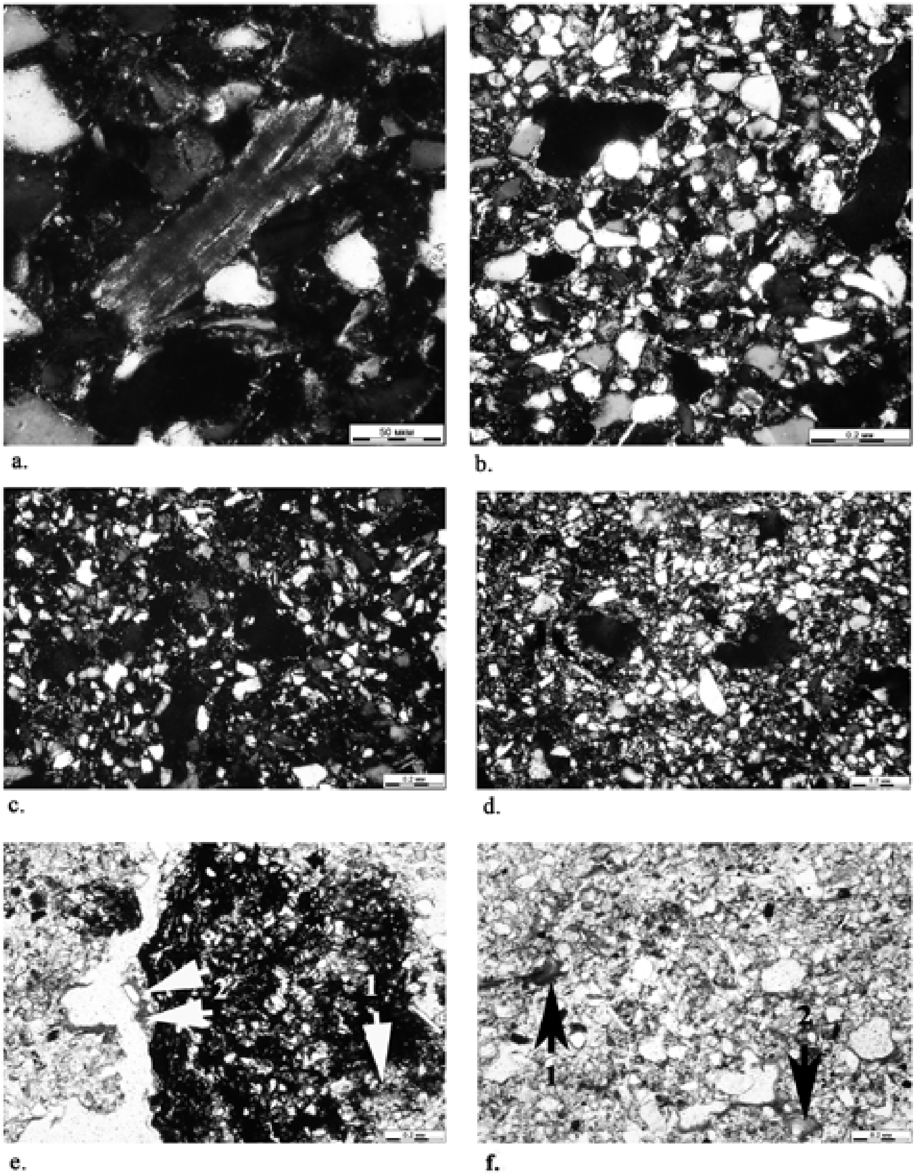


Figure Br11 – 1.18. Section 07-03: micromorphological features. a – altered biotite grain in 3EBtgb horizon (Gnezdovo soil); b – clay coatings in 3EBtgb horizon (Gnezdovo soil); c – clay impoverished zone in 3EBtgb horizon (Gnezdovo soil); d – compound coating in 3Ebtgb horizon (Gnezdovo soil); e – 1 – Fe-nodule incorporated a fragment of clay coating (class 5) partly covered with 2 – compound coating in 3Btgb2 horizon (Athlantic soil); f – Fe-enriched (class 1) and Fe-impoverished (class 6) coatings in the (3BE)tg horizon (Athlantic soil).

Sin-genetic textural differentiation of the profile most probably should be concluded as far as a drop of textural pedofeatures and zones impoverished by plasma are observed in (3Ab)t horizon and particle size distribution of clay fraction (<1 μm) reveals eluvo-illuvial pattern of differentiation (Fig. 1.17 a). Textural pedofeatures in this profile are mostly presented by alternation of bleached clay coatings and not well oriented Fe-clay coatings. Such complex of textural pedofeatures is a clear evidence of seasonally alternating phases of reduction and oxidizing.

Point 4.3. Early Subatlantic floodplain.

Section 07-01 represents the destructive variant of the floodplain created by the 2.6 ka extreme event. Erosion left a depression that began to fill quickly with alluvial fines. At depth under 5.0 m silty sands occur indicating the first, most active phase of filling. Above the level 5.0 m deposits are mainly loams and silts. At their base numerous woody debris concentrate which is typical for standing water pools adjacent to active channel. A 30-cm trunk at 5.0 m was radiocarbon dated at 2370±80 (LU-5862). At depth 1.9-3.8 m lie loams interbedded with peat. In the peat layer at 3.4 m a root part of a trunk in the living position was found (date 1850±40 IGAN-3706). At 3.0-3.1 m were found bone of horse (not dated because of insufficient quantity of collagen) and wood chips dated at 1200±80 (ЛУ-5866) and 1250±60 (ЛУ-6076), i.e. 650-990 AD cal (95.4 %). The latter may belong to human activity at the earliest time of the Gnezdovo settlement. Upper 1.9 m are sands and silty sands indicating rise of floods.

Age-depth model produced from a series of radiocarbon dates (Fig. 1.19 permits estimation of boundaries between the two units with different sedimentation rates that might correlate to the Late Holocene palaeohydrological epochs: low sedimentation rate and low floods epoch - between 2.2 - 0.6 ka BP, high sedimentation rates and high floods epoch – since 0.6 ka BP.

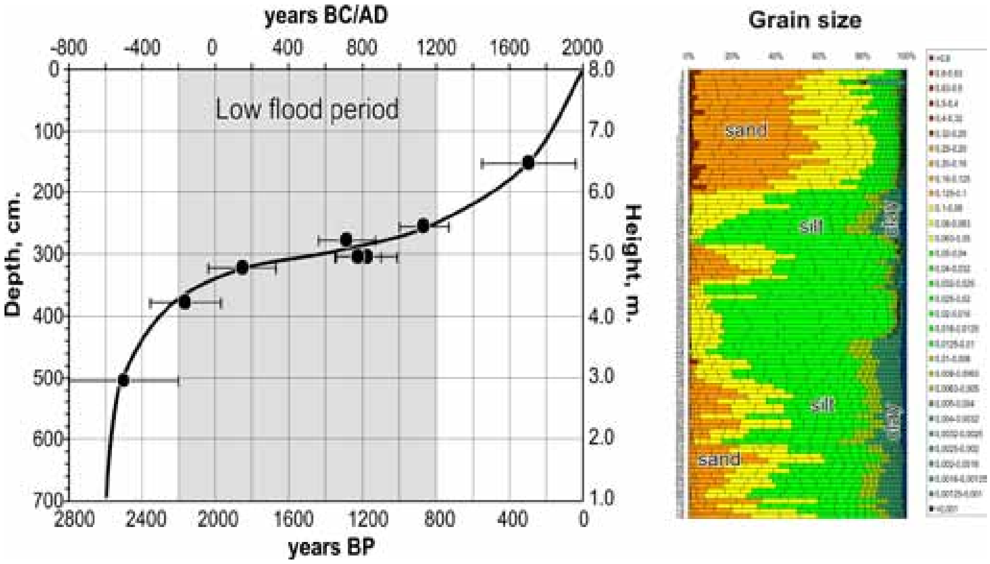


Figure P10 – 1.19. Lithology and sedimentation rates at section 07-01: floodplain created in the beginning of the Late Holocene (FP-2).

Point 4.4. Central area of the floodplain part settlement

Section P-8 represents a constructive type of FP2: it was a zone of prevailing sedimentation during the 2.6-ka extreme floods and got relatively high topographic position, which favored active and diverse activity of Early Medieval people at the site. The arena for this activity which started at the VIII / IX c. boundary was palaeogeomorphic surface fixed by well developed soil. This soil starts from the depth of 110 cm with anthropogenic material of occupation deposit including numerous artefacts. Anthropogenic horizons in terms of World Reference Base for Soil Resources are ascribed to Urbic material. Nearly undisturbed Albic and Argic horizons of Gnezdovo Albeluvisol were described under these horizons. This soil (excluding its Urbic horizons) is generally the same as in above described section 07-03: well differentiated, combining variable textural and redoximorphic features in mid and low horizons. All classes of textural pedofeatures including class 5 which is specific for Gnezdovo soil, defined for undisturbed Gnezdovo Albeluvisol of the 07-03 section are also registered in P-8 (Table 2, Fig. 1.20 e). There are two additional classes in the assemblage of textural pedofeatures: classes 3 and for. Class 3 includes silty-sandy or unsorted material, often including organic matter (Fig. 1.20 a, d), the class 4 is humus enriched pedofeatures (Fig. 1.20 c). These classes of textural pedofeatures were described only in anthropogenically transformed soils under early medieval occupation deposits. This fact allows us to ascribe 3 and 4 classes of textural pedofeatures to human impact. Besides that there are numerous evidences of biogenic activities such as coprolites (Fig. 1.20 a), and artifacts in layers of habitation deposit, fired stones in particular (Fig. 1.20 b). Processes of accumulation of iron- and humus-enriched illuvial material and formation of Fe-Mh-noduls seem to be more o less synchronous process and most probably related to a final phase of Gnezdovo soil development.

The next phase of pedogenesis with faint signs of lessivage related approximately to 800-600 years BP is recorded in an upper buried soil (starting from the depth of 50 cm).

Table 2. Section P-8, textural pedofeatures.

Horizon	Classes according the composition and morphology (see below the table)						Relative abundance
	1	2	3	4	5	6	
A	–	–	–	–	–	–	–
AC	–	–	–	–	–	–	–
2Ab	–	–	–	–	–	–	–
2EBtb	+	+	–	–	–	–	+
2Bt	+	+	–	–	–	–	+
3(Aub1)t	+	+	+	–	–	–	+
3(Aub2)t	–	+	+	+	+	–	++
4EBtg	–	–	+	+	+	+	++
4Bt1	–	–	+	+	+	+	+++
4BtC	+	–	+	+	+	+	+++

Classes of textural pedofeatures according their composition and morphology (+ occur, – do not occur): 1 – Clay, Fe-oxides and / or humus containing, low anisotropic; 2 – Sandy-silty, well sorted; 3 – Silt and silt clay, unsorted, with admixture of sand, organic (humus impregnation or/and charcoal dust); 4 – Clay with admixture of organic, grayish colour in polarized light, low anisotropic up to isotropic, diffuse or flecked extinction; 5 – Clay, with bright self and interference colors, sharp strait or wavy extinction; 6 – Clay, pale or nearly colorless, impoverished by iron oxides.
Relative abundance is estimated in following classes: – no, + few, ++ common, +++ abundant.

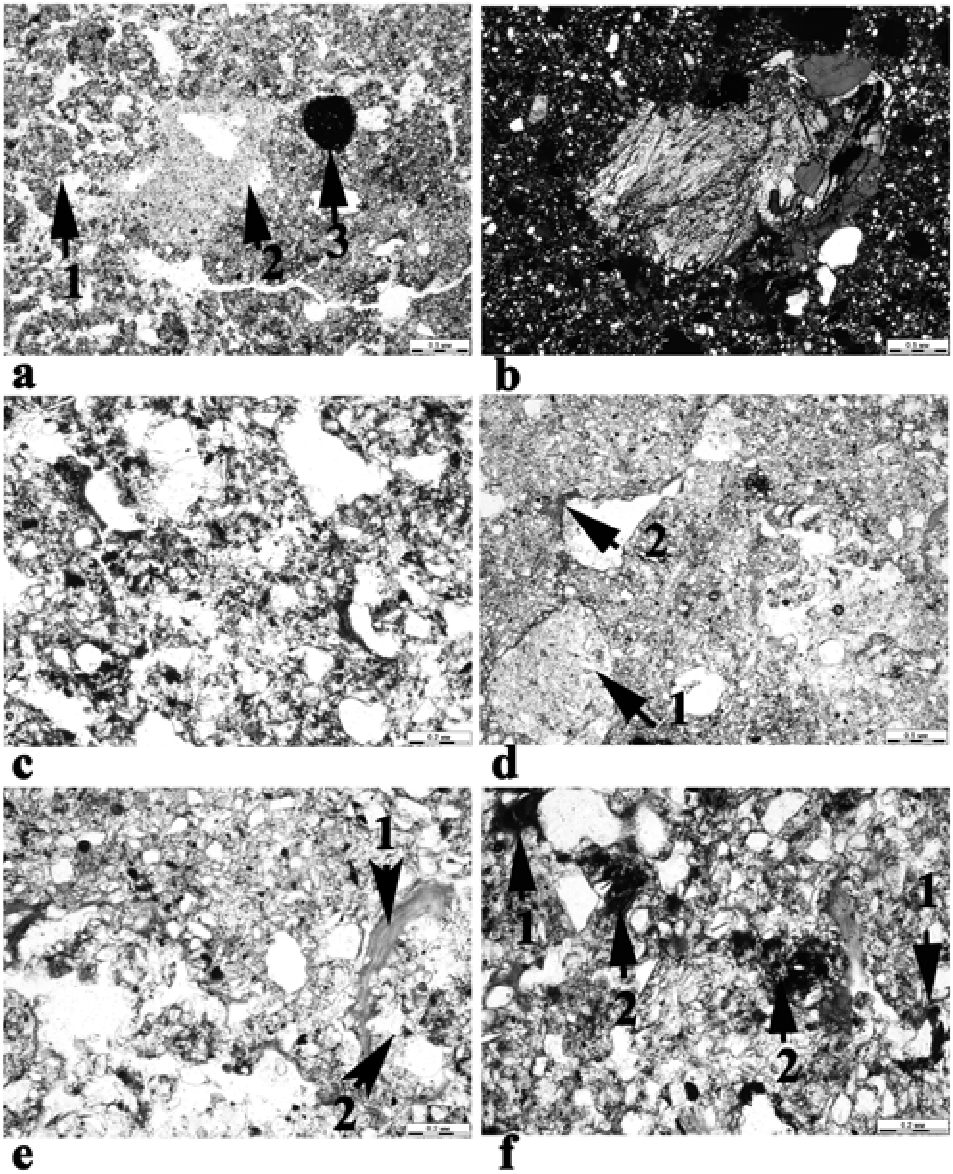


Figure Br12 – 1.20 Section P-8: micromorphological features.
a – 1- welded coprolites; 2 - Silt infilling (class 3); 3- Fe-Mn nodule in 3(Aub1)t horizon (occupation deposit) of Gnezdovo soil; b – Fired stone: cracked and altered along the cracks in 3(Aub1)t horizon (occupation deposit); c – Humus-clay coatings (class 4) in 4EBtg horizon of Gnezdovo soil; d – 1 – Silty infilling and 2 – humus-clay coatings in 4BtC horizon of Gnezdovo soil; e – Clay coating (class 5) and unsorted infilling (class 3) in 4BtC horizon of Gnezdovo soil; f – Fe-enriched coatings (class 1) and Fe nodules in 4BtC horizon of Gnezdovo soil.

Systematic *archaeological investigation* of floodplain sector started in 1999 and during the fieldwork four different function area were identified.

1. "Manufacturing" area is situated near the Kamyshi lake and is characterised as a jewellery and forgery center having also some dwelling houses and household buildings. The alternating record of those is dated back in the range of the second quarter of the 10 century up to the border of the X^{th}-XI^{th} centuries.

2. “Periphery ” (near-terrace) area is located at the boundary of the flood-plain and the terrace. The remnants of dwelling houses were fixed within the area which were dated back to the beginning of the XI^{th} century representing the final stage of the settlement existence.

3. “Harbour” area at the north-east bank of the Bezdonka lake, which probably was used as the inner harbor. The wooden planking supposedly could have been used as “hards” in the warf of the ancient Gnezdovo. The occupation deposits of this area as a whole could be bated back to the X^{th} century.

4. “Riverbank” area is located at the southern boundary of cultural layer near the Dnepr ancient river channel bank within the “beach”. The traces of different kind of human riverside activity were revealed. The studied features could be dated back in the range of the second quarter of the 10 century up to the border of the X^{th}-XI^{th} centuries.

The central and the most elevated part of flood-plain sector of settlement is named “manufacturing” area as at the beginning of archaeological studies there was revealed a system of jewellery and forgery workshops. The finds of forgery furnaces and especially jewellery workshops is considered as a great rarity for the Viking age. The traces of manufacturing shops often are absent even in the case of finds presented with mould and rejected materials. It can be explained by the fact of base metal fusing could be performed in small fire places adapted specially for one crucible. Such primitive constructions could be attributed as a manufacturing workshop only by usage of special methods. The objects of the Gnezdovo flood-plain are of special interest as those can give the information on the different types of the manufacturing workshops. The data allows to trace the dynamics of forgery constructions, so we can speak about four succeeding construction types.

1. The most early object presents the deepened two-camera construction. The numerous slags accumulated in one of the camera indicate the connection of this object with the metal manufacturing. The second camera was adapted for bellows or perhaps was used for the flux storing. The similar scheme is observed at Medieval Trondheim at the 12th century excavations. the complete absence of the crucible fragments may support the assumption of exclusively ferrous metal manufacturing at the ascribed workshop.

2. The furnace of the second period was greatly distinct: it provides the cuplike pit surrounded by the low clay wall protecting the bellow from high temperature heating. A nozzle was found among the fragments of fired clay. Quite the same type of furnace was reconstructed at the Hedebu archaeological materials. It is assumed that such workshops were multifunctional and applied as jewelry and/or iron forgeries, the later being documented by crucible finds as well as numerous ferrous slags. The combination of jewelry and forgery is typical for the early medieval artisans.

3. The deepened furnace with marginal clay wall was succeeded by the construction with the preserved pit-trench. Its form is complicated by the step cut at the northern pit wall. A small stone fire place is sited at the step.

4. Most interesting and well preserved objects are related to the final period of the manufacturing center existence. The central part of the manufacturing area is presented with remains of a large stony fireplace. The fireplace is a joint by a pit of regular oval form with flat bottom and vertical walls. Probably such a near-furnace groove was designed for more comfortable work with bellows mounted at flooring above the pit. The mycological study of the near furnace pit filling demonstrated the presence of spores of keratinophilous fungus developing on wool, leather, hair and skin. Perhaps the later is an evidence of leather bellow usage at this workshop.

The occupation deposit related to the final period is abundant of finds, the majority of those being applied in the manufacturing processes. The crucibles are predominant among the casting implements.

The studying of crucible filling, ingots, metal spitting and manufacturing wastes as well as final products gave the opportunity to attribute the content of row materials of jewelry workshop: silver as well as a high standard gold, pure copper, bronze, brass and pewter were applied.

The ascribed workshop is considered as a center of the studied territory, but there were also several other types of constructions located: deepened household buildings for food storage and presumably living buildings.

Figure M-01 – 1.21. Selected finds from the floodplain area.
A – Dragon-shape mount. Flood-plain area. Central part; B – Reliquary-cross. Flood-plain area. Central part; C – Tongs. Flood-plain area. River-side area; D – Rowlock. Flood-plain area. “Port” area.

One of the most interesting objects ascribed in the study of so called "manufacturing area" was a land use boundary. It served as a western border of the section where a jewelry-forgery workshop was located. Later just at this point the succeeding each other pole fences were constructed. Thus the land use boundary was replaced by the fence. One more boundary was revealed at 13 meters to the west being the argument for the manor character of the lay out and gives materials to compare the planning of Gnezdovo settlement with the former of North European early urban centers, such as Kaupang and Ribe. It could be especially pointed out that the occupation deposit of the manufacturing area comprised numerous fragments of thin-wall glass vessels and amphorae. These objects traditionally are considered as indicating a high social rank of the owners. Such finds could serve as an indirect evidence of a high social rank of the manor owners possessing the jewelry workshop in the manor territory.

Selected archaeological finds from the floodplain are shown on Figure 1.21.

Shortly after decline of the Gnezdovo settlement cultural layer was buried by overbank silts and fine sands due to the rise of floods. Floodplain inundation and alluvial sedimentation on it resumed within the XIIIth century as is exhibited by OSL date 0.777±0.57 ka (GdTL-1237) at the base of overbank alluvial unit (Fig. 1.22). Most active flooding indicated by distinctive unit of laminated sands at depth 15-35 cm occurred in late XIV– early XV c. (OSL date 0.594±0.62 ka, GdTL-1236). After that alluvial sedimentation at the site declined. The last century was probably characterized by lowest floods in the last 800 years as is evident from modern floodplain soil Contemporary soils are developing within sin-sedimentary model of pedogenesis. Soil mantle of the floodplain nowadays is typical for seasonally inundated areas. Contemporary soil mantle includes a variety of Haplic, Gleyic, Stagnic, Histic Fluvisols. Zonal processes of vertical profile re-distribution of silicate material, iron and humus do not proceed nowadays. Only humus (or peat) accumulation, usually combined with short term (related to seasonal floods) or long term processes of reduction and oxidation in Stagnic and Gleyic conditions are ongoing.

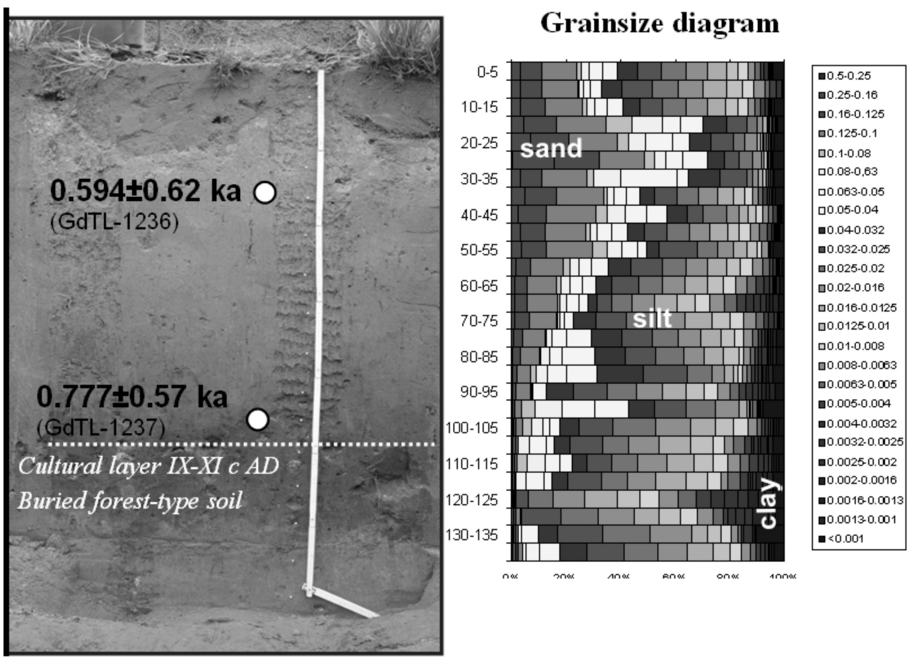


Figure P11 – 1.22. Section P8: another kind of FP-2 floodplain; sedimentation break in the first millennium AD and resume of sedimentation in the second millennium.

Section DP.

In the section that cut the levee at the Fp2 / Fp1 boundary characteristic sloping buried surfaces were found with microfaults indicative of sediment disturbance by gravitation (Fig. 1.23). These structures were most probably associated with steep bank created by lateral erosion by the river. Therefore they relate to the moment when the right river bank stayed at the Fp2 / Fp1 boundary. This river palaeobank was OSL dated by overlaying sediments at depth 1.4 m at 1.14±0.14 ka (GdTL-1235). Similar result was obtained by radiocarbon dating of charcoal at 2.3-2.4 m: 1050±200 (GIN-14377). It means that around the IX-Xth c. the river contacted directly the southern border of the settlement.

Figure P11 – 1.23. Section DP (2010): gravitational deformations of overbank sediments indicative of close location of palaeochannel bank.

This site location made to expect in a frame of archaeological investigations some peculiar objects connected with the shore line. Some traces of manufacturing which could be connected with river boat service, such as tar extraction and black-smith handicraft fire-places were revealed at this territory.

The tar-works pit was round in plane, its walls were sufficiently heated. An additional small pit is located at the bottom and was assumably used to maintain a vessel for tar accumulation. The pit was filled with charcoal.

A system of black-smith handicraft fire-places was excavated at the river-bank area. The fire-places were constructed one after another on the same place, Each fire-place was covered up with earth after the end of utilization and a new one was constructed. As a result a great artificial hill was formed.

The fire-place of final stage of settling was well preserved, the big blacksmith's tongs and the scythe were found nearby. A great number of slags serve as an evidence of activity connected with ferrous material working. The numerous boat rivets (including the whole, half-finished products and broken ones), were found. So we can suppose that this manufacturing area could be connected with river boat service.

The remains of some deepened structures were investigated within the river bank area. The structures had a form of oval pits with a charcoal layer at the bottom being the trace of burned wooden constructions. Its function is unclear. The results of biomorphic analyze showed a high content of moss phytolith. Mosses are not characteristic for a beach area, thus we can suppose, that moss came into the area with the turf, used for roof covering. Or maybe the moss was used for warming the walls. These data serve as indirect evidence of existence of ground-based part of deepened structures.

The Byzantine amphora, which is very remarkable and infrequent find was found in one of the deepened construction. Within other construction a set of beads as much as 50 items was found. Thus all the facts and first of all the location of this site let us to assume that the constructions in question are the riverside seasonal storage remains. It is evident that that this area could be connected with the “port economy” of Gnezdovo.

Point 4.5. Eastern bank of the Bezdonka Lake: sedimentation, traces of human activity, pollen data.

Core S20W60 in the center of the lake opened loams and sandy loams and a layer of peaty loam - loam with high content of plant macrofossils at depth 2.5-3.1 m, or 0.5-1.1 m from the lake bottom (Fig. 1.24). Reconstruction of local environment was made according to analysis of biological microremains (O.N. Uspenskaya, Russian Academy of Agricultural Sciences). Four stages were distinguished (note: depth scale begins at lake surface, lake bottom is at 200 cm): “wet floodplain” (575-445 cm), “dry floodplain” (445-370 cm), permanent lake (370-200 cm). Sediments at depths 370-325 cm and 255-260 cm indicate most shallow conditions, depths 235-250 cm and 200-220 (most recent) – the deepest conditions.

Radiocarbon dating was produced for the PS (peaty silt) layer. Many inversions evidence that the PS layer was disturbed. Majority of dates is contained within the range 800-1800 years BP. Probably this is the interval during which the SP layer was formed. It is confirmed by adjacent cores where the base of PS is dated at 1700-1800 years BP and the roof does at 700-800 years BP. Date 395±45 shows that turbation of sediments occurred or resumed during the XVIth century or later.

Now the Bezdonka Lake has maximum depth of 2.0 m. Its level is now regulated by a spillway cut through the main levee to the Svinets River. In the bottom of the spillway at depth of 2.0 m layer abundant with pine chips was found. Wood was radiocarbon dated to 1260±80 BP (LU-6108), or 840±180 AD cal. (95.4 %). Regardless whether the chips belong to the Gnezdovo cultural layer or to pre-Gnezdovo times, bottom of the spillway and level of the lake were about 2.0 m lower than they are now. Lake surface was at the level of today's lake bottom.

According to the above dating of the SP unit, 1000 years ago the lake bottom located in the upper part of the peaty silt unit, i.e. 60-70 cm below the modern bottom. Consequently, thickness of sediments accumulated in the lake in the last millennium is by

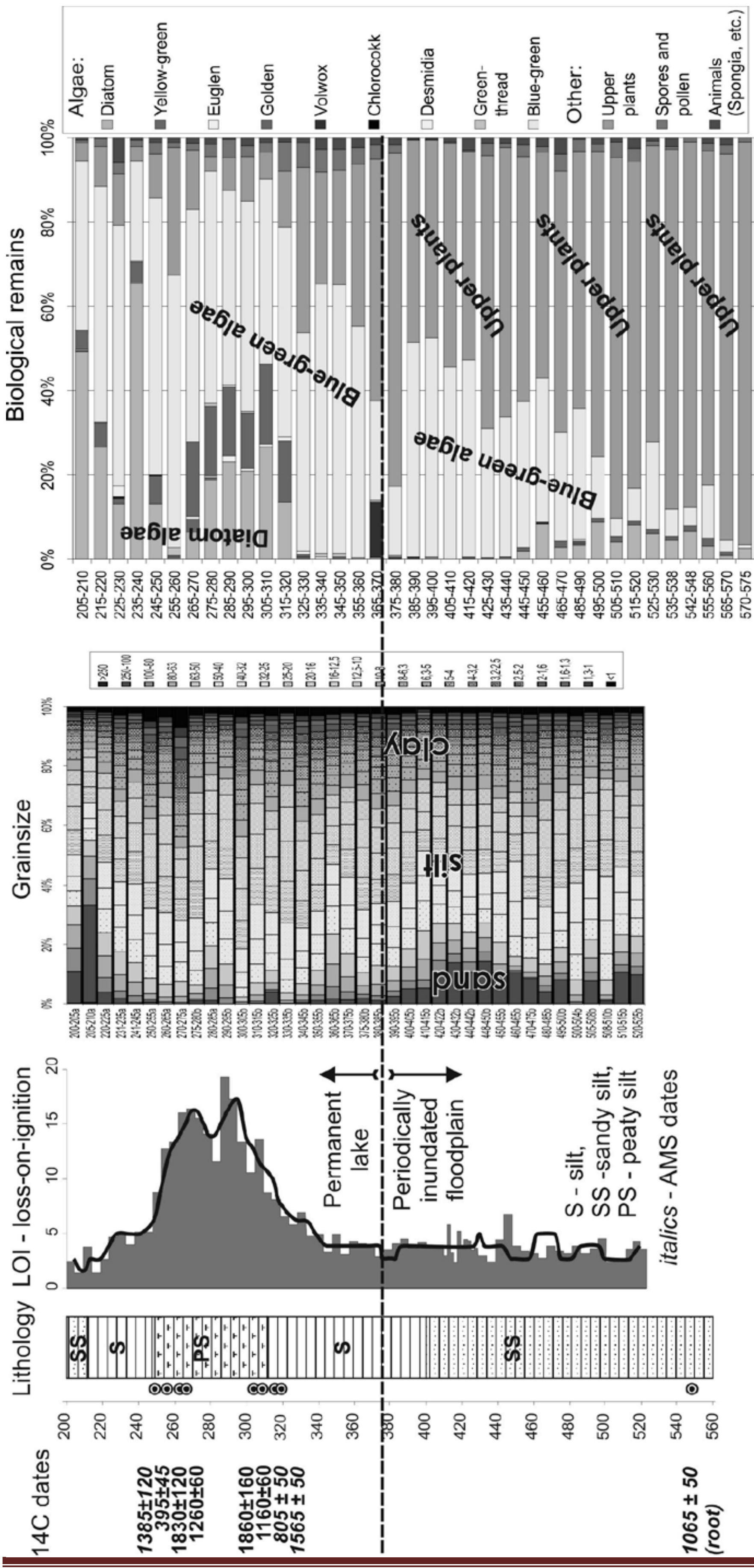


Figure P12 – 1.24. Age and lithology of the Bezdonka Lake bottom sediments (core S20W60). AMS dates are in italics. Depth scale: zero at lake surface (water depth is 2.0 m).

1.3-1.4 m less than that in the spillway. Therefore the lake depth 1000 years ago was by 1.3-1.4 m less than now: maximum depth was 0.6-0.7 m, lake area was two times as less as it is today. The other evidence of reduced dimensions of the lake 1000 years ago is the root of willow found at depth 5.5 m and dated to 1065 ± 50 BP (uncal): lake banks covered by willow woods were much closer to the centre of the lake than they are now.

To summarize, the Bezdonka Lake development indicates major events in local fluvial history. After extreme floods around 2.6 ka BP the depression formed which opened to the river channel and functioned as wet low floodplain. High sedimentation rates were raising the surface and in a while it became more dry. Permanent lake appeared when this depression was isolated by channel levee which formation began when the channel shifted to its edge. It happened about 2-2.2 ka BP. Since this moment the lake area and depth were governed by sedimentation rates in the lake and in the outflow channel (spillway). General tendency was increasing lake depth since it's formation till now.

The lake depression was ever one of the lowest places in the Gnezdovo segment of floodplain. During the time of the Gnezdovo settlement lake level was almost 1.5 m lower than now. Therefore artificial constructions at lake banks (see below) were not so wet as they are now. Nevertheless, unlike the top places of the floodplain, in the lake depression river flooding and alluvial sedimentation never broke. Cultural layer at the lake banks and in some other low parts of the floodplain usually intercalate with overbank alluvium (split CL). It may be used to estimate flood levels at the time of it's formation. Split CL is not found higher than 7 m above the modern river (Fig. 1.25). Most probably, this is the level of the highest floods in the Xth-XIth centuries. It was at least 3 m lower than levels of recent floods.

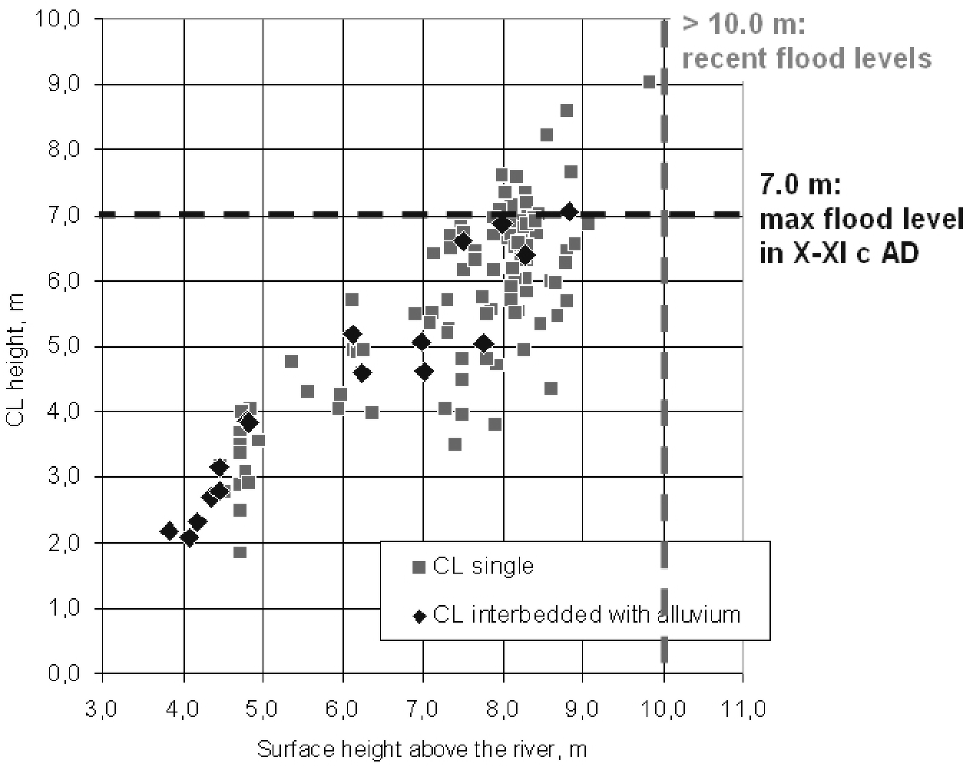


Figure P13 – 1.25. Estimation of flood height in the X-XIth c. AD via elevation of split cultural layer (CL intercalated with alluvium).

Pollen analysis was accomplished for a 335 cm core of Bezdonka sediments. A stratigraphy of the core seems to be intact. The upper part of the core is gyttja with variable amounts of plant remains, and a mineral composition of both sandy and silt particles. At a depth of 94 cm it is silty peaty gyttja and peaty silt. At the 155 cm the character of material changes qualitatively to more or less mineral sediments: clays, silty clays and silts with FeS and plant remains.

The volume of sample was measured and recent *Lycopodium* spores in tablets were added to determine concentration of pollen. Sample preparation followed the standard procedure described in Moore, 1991. The pollen reference collection of the Department of Earth Sciences, Uppsala University, together with keys by Fægri and Iversen (1989) and Moore et al. (1991) were used for pollen identification. To ensure the representativity of pollen counts about 1000 tree pollen grains (for rare samples with extremely low pollen concentration not less than 200) were counted at every level.

Pollen percentages were calculated by the "TILIA" program, based on the sum of tree pollen plus non-arboreal (herbaceous plants) pollen. Black areas on the diagram show the registered pollen in percentages, while white areas show the actual percentages with equal exaggeration. Anthropogenic indicators were defined according to Behre (1988) and Berglund et al. (1986). Grouping of plants was carried out applying a system by Königsson et al. (1995). Pollen assemblage zones were determined visually, on the basis of distinct changes in the vegetation.

The full pollen diagram worked out for oxbow lake sediments is presented in Fig. 1.26. On the evidence of pollen spectra the whole diagram undoubtedly corresponds to Subatlantic. Pine, spruce and alder dominate among tree pollen throughout the diagram only changing their proportion. The lowermost part of the diagram corresponds to the early Subatlantic (SA1), showing a slight predominance of spruce (*Picea*) pollen which is characteristic for the region. Then birch (*Betula*) takes up the first place among tree pollen followed by alder (*Alnus*), pine (*Pinus*) and *Picea*. The last significant phase is marked by the dominance of *Pinus* and general decrease of arboreal pollen exhibiting extensive deforestation.

First the diagram was divided into zones and subzones corresponding to major and minor stages of natural (climatic, successive) and, especially, human induced landscape development. Here the only major zones generally corresponding to big divisions in litho-stratigraphy of the core are discussed. These pollen assemblage zones characterise the basic phases of landscape development.

Zone I: 335–155 cm. This part of the diagram is characterised by high amounts of tree pollen. Originally, the area was densely forested and the presence of broad-leaved trees, mainly oak (*Quercus*) and elm (*Ulmus*) was still considerable. Human impact is not very significant here but nearly constant based on curves of cultivated plants and plants favoured by culture (Hemerophilous). Wheat absolutely predominates in this zone among the cultivated crops, but buckwheat, rye and hemp are also present. There are also some indicators of grazing, namely *Achillea*, *Pteridium*, and *Melampyrum* accompanied by an observable amount of ruderal plants and weeds (*Polygonum aviculare*, *Chenopodeaceae*, *Artemisia*, *Rhinanthus-type*, *Rumex acetosa*). Human impact ceased in the middle of the zone by a short stage of landscape recovery and forest invasion. Here a rise of *Betula*, together with a new increase of alder at the expense of *Pinus* and *Picea*, most probably resulted from human induced successions. Willows (*Salix*) and ferns (*Polypodiaceae*) are components of the alder forests.

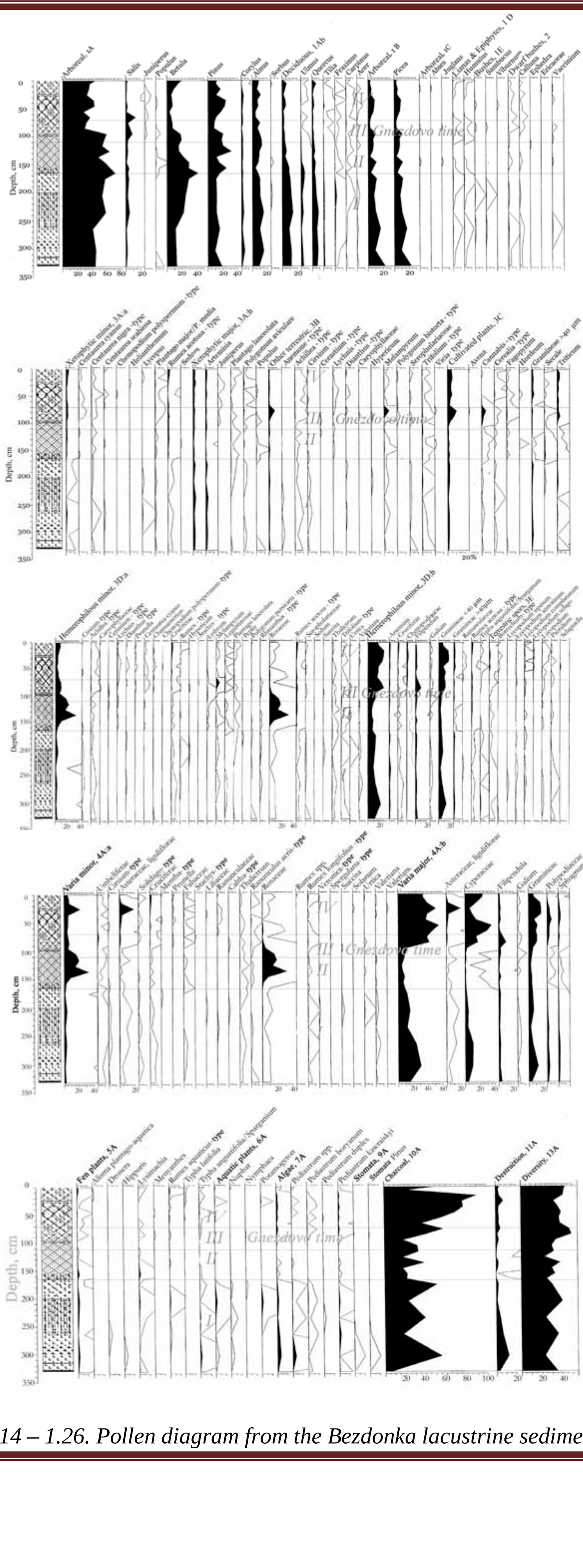


Figure Br14 – 1.26. Pollen diagram from the Bezdonka lacustrine sediments.

Presence of typical aquatic plants such as *Nuphar* and *Nymphaea*, and lots of algae testifies to limnic conditions in the sampling site. Low concentrations of pollen and high values of the Destruction coefficient indicate high sedimentation rates.

Stratigrafically this part of the core is represented by more or less mineral sediments. A number of hiatuses appear in the lowermost sector. That, together with repeated occurrence of sharp-bordered sandy-silty layers, most probably are due to repeated high spring floods of the Dnieper river.

Zone II: 155–110 cm. This pollen assemblage zone generally coincides with the next big stratigrafic division represented by peaty gittjia and peat with a relatively low admixture of mineral phase. The curve of pollen concentration indicates a heavy increase here and reaches its maximum. Such an abrupt change in pollen concentration, together with the rapid decrease of algae and all taxa of aquatic plants followed by their complete disappearance point to a critical change in the character of sedimentation. The oxbow lake dried up and peat formation established. Curves of some xerophytic plants increase steadily. These elements point to a climatically dryer phase of landscape development, characterised by low sedimentation rates, and low and irregular spring floods that did not affect the sampling site.

Agricultural activities diminished at this time but still took place according to the curves of cultivated plants and other culturally induced plants.

Zone III: 110–70 cm. The zone corresponds to the most extensive human impact reflected in the diagram. A particular feature of this zone is the extraordinary amount of *Cannabis* in the pollen spectra (more than 5 % of pollen sum). High quantities of *Cannabis* are regarded to be a specific characteristic of the Viking Age in the Baltic region (Andersen, 1984). Well ^{14}C dated diagrams were worked out recently for Novgorod and Ryurikovo Gorodische, where layers dated between the 9 and 12 centuries AD also revealed an extreme peak of *Cannabis* (Königgson et al., 1997). All this allows us to consider the zone III as corresponding to the time of Early Slavonic/Viking Age settlement at Gnezdovo.

The zone starts from an abrupt and drastic deforestation coinciding with a heavy rise in the charcoal curve. All curves of trees go down steeply. The curve of deciduous trees reaches its minimum. The sum of tree pollen is less than 35 %. Thus the originally forested area was turned into a more or less open landscape. Outstanding maximums of wheat and hemp with a considerable share of buckwheat pollen show their remarkable place in the economy of the settlement. Evident peaks in the curves of ruderal taxa, weeds, and grazing indicators emphasise variable and extensive land use. Consequently, this period is particularly remarkable for all types of human impact: deforestation related to everyday needs (fuel wood, timber etc.), fire clearance for husbandry, extensive and variable crop production, pastoral economy, as well as other habitation-related activities.

An important point is that the zone of the most intensive human impact falls at the very end of the climatically dryer period when the Dnieper's floods ceased, ant the floodplain surface was relatively dry and stable. This is obvious both from stratigraphy and pollen spectra. At a depth of 94 cm peaty sediments are replaced by clay gyttja and then silty clay gyttja. Algae, and aquatic plants appeared again which points to a re-establishment of limnic conditions in the oxbow-lake after the previous stage of overgrowth.

Zone III: 70–0 cm. This part of the diagram exhibit signs of a slight landscape recovery after the diminishing of early medieval settlement (decrease of cultivated plants accompanied by a rise of the tree pollen curve) followed again by enhanced human impact. After extensive deforestation in early medieval time the curve of tree pollen never reaches its initial values. All anthropogenic indicators show a considerable drop in the beginning but nevertheless persist in the upper part of the diagram.

Total pollen concentration decreases heavily in the beginning of zone III indicating a rise in sedimentation rates. Sediments contain more and more silty and even sandy particles. The subsequent rise of pollen concentration in the uppermost horizon is most probably due not only to a new increase of sedimentation rates but also high activity of soil biota feeding on pollen. Considerable amounts of algae and aquatic plants are registered in this zone. Thus this last phase of landscape development is characterised by limnic conditions in the sampling site (or its closest vicinity), re-established intensive floodplain sedimentation and persisting human impact.

Pollen analysis of the Bezdonka lacustrine sediments allowed to draw following conclusions on Subatlantic development of vegetation and landscapes. Landscape development of the Gnezdovo micro-region, as reflected in the pollen diagram, was strongly affected by land use activities of population throughout the investigated period. Originally the area was densely forested. These were mixed forests with a considerable proportion of broad-leaved trees (10-15 % of pollen sum), especially oak. Phases of slight deforestation and increased human impact (increase of cultivated plants, grazing indicators, plants favoured by culture in the pollen spectrum) correspond to periods of population influx. These periods alternate with phases of landscape recovery after the decline of land use activities.

Signs of natural climatic change are evident in the middle part of the section. This was a period of slight aridization and reduced sedimentation on the floodplain. It is reflected by a change of sedimentation regime, the character of sediments and overgrowth of the oxbow lake, slight natural deforestation and the rise of dry-meadow plants.

The zone of the most significant and variable human impact is referred as the Slavonic / Viking Age Gnyezdovo settlement (1100-1000 BP) and falls at the end of a climatically dryer period when Dnieper's floods ceased; the floodplain surface was relatively dry and stable. Deforestation reached a dramatic extent at this time. Forests were most probably superseded by that time, particularly due to land use activities of the population. A heavy rise of cultivated plants in the pollen curve testifies to the importance of local crop production in the economy of the settlement. Wheat, hemp and buckwheat predominated among cultivated crops. Grazing activities also took place.

The decline of the settlement is denoted by the drop in cultivated plants, plants favoured by culture and slight forest invasion. This phase of landscape recovery is followed by the next stage of deforestation and expanded agricultural pressure, which corresponds to the contemporary state of the landscape.

The interpretation of Gnezdovo site like a key-point on the road from the Varangians to the Greeks allowed to assume the existence of structures servicing the fluvial route, but until recently no complexes or areas related to port activity here was discovered. A special task within the framework of the reconstruction of the topography of the settlement was to identify the areas which could be used for reception, fix, loading/unloading of ships and boats.

Participation of Gnezdovo inhabitants in navigation was documented by indirect data, predominantly by the finds of a large quantity of boat rivets both within the occupation deposits and in the graves and prominent rise of hemp in pollen spectra of the Gnezdovo time. Prominent maximum of hemp in pollen curves is very characteristic for the Viking Age in Scandinavia and is believed to be related to ship building (rope production). In addition to archaeological data we have the written sources evidence. Byzantine Emperor Constantine Porphyrogenitus in the mid of Xth century wrote that

Krivichy (local Slavonic tribe) constructed their monoxila (it means “dig-out”) in the hill-fort of Smolensk and navigated to Kiev, capital of Ancient Russia with Rhos (it means Scandinavian incomers).

“The monoxila which come down from outer Rhosia to Constantinople are from Nemogardas (Novgorod) and other from the city of Miliniska (Smolensk). Their Slave tributaries, the so-called Krivetaienoi (Krivichy) cut the monoxila on their mountains and come down to Kioba (Kiev).”

Constantine Porphyrogenitus “De administrando imperio”.

The main problem in search of fluvial harbor structures is the inexpressiveness of early medieval river wharf constructions. At the initial stage landing places could not have had no special constructions: the boats and people were simply pulled out on the bank. Naturally the archaeological criteria are not valid here, excluding perhaps the unical finds of boats or their fragments. The most primitive constructions were stones or posts used for mooring. At best the berth zone as at the sea coast as well as at the river bank could have been framed by the wooden planking (hards in order to approach to the water line).

The structures which could be interpreted as port ones were firstly ascribed near Bezdonka lake. This inner lake is located at the foot of the Central Hill-fort. It is connected by a channel to a tributary of Dnieper.

Two levels of planking were discovered here. The latest one represented a rather complicated construction – it was a system of wooden planks, under which the mats of birchen bark were lain. May be these mats were used like a dampproof course. Two levels of planking were discovered here. The earlier planking was more primitive: it was made of large planks, superimposed straightly on the ground. It is impossible to find out how those plankings were used. Such planking could be applied for pulling out the boats or inversely for launching and. perhaps for repair. At the same time these simple construction could be used for everyday purposes like fishing and laundering. It is impossible to find any archaeological criteria to divide these two functions.

At the lake bank two more objects were discovered which presumably also could be associated with navigation. First of those is the trench directed to the terrace from the Bezdonka lake, dated as the most ancient construction. The traces of wooden panelling of thin logs and perches are observed at the southern side of this trench. It could be assumed that the trench was used for pulling out the boats from the lake. Thus this construction could be interpreted as small inner portage.

The filling of trench contained one of our most impressive finds. It was a boat rowlock – a symbol of Gnezdovo harbor. The rowlock was decorated with ornamental pattern of Scandinavian origin.

The second object presumably connected with the navigation is a finely preserved picket rooted in the ground at one of the most ancient uncovered surfaces. This picket has some traces of a bast rope. It could be assumed that it was one of “mooring picket”, one of most ancient harbor construction.

At the territory of the “harbor area” the traces of peculiar handicraft activity were ascribed in a form of tar-works. The pit for tar extraction had a depth of one meter, its lower part was filled with dense fatted charcoal interpreted as relics of tar sublimation. The analyses of remnants showed the presence of coniferous bark.

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