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Buried Soils in the Floodplains of Small Rivers of Middle Volga.

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ABSTRACT

Synchronization processes of soil formation and deposition of alluvium brought to the flood plain with affluent and flood waters are characteristic for floodplain soils. In the presence of natural terrains in the watersheds warpage is gradually processed in soil-forming process, layering of sediment disappears and good humus soil is formed in floodplain. In the floodplains of small rivers of different terrain zones of the Middle Volga the age of three buried hydromorphic soils is determined by radiocarbon method. This allowed to determine the periods of stabilization and strengthening of the accumulation of floodplain alluvial during the last seven thousand years. Formation of the lower buried soil at the depth of 3.5 m (age about 6800 years) coincides with Atlantic period - the Holocene climatic optimum. The development of the second layer of buried soil (with the age of three-four thousand years), which is located at a depth of 1.8 m from the day surface, is at the end of the Holocene subboreal period. The uppermost buried soil, the age of which is about 1200-2400 years was developed in Sub-Atlantic period of the Holocene. In the past 30-600 years, there was an intensive accumulation of alluvium and the formation of warpage on top of the buried soil, largely due to human activities. As a result of anthropogenic changes in basins of small rivers accumulation of material on the floodplain increased, and at the same time the rate of soil formation started to lag behind the rate of accumulation.

Keywords: floodplain, alluvium, accumulation, the radiocarbon method, spore-pollen method.

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INTRODUCTION

The study of soils in the flood plains of small rivers is necessary to restore the character of sedimentation in the bottoms of river valleys and their connection with the modern terrain. The average rates of soil formation in the temperate zone of the Russian Plain constitute 0,5-1,5mm a year. The total duration of the formation of well-developed hydro and automorphic soils ranges from 500 to 1500 years [1, 2]. The soils on flood plains are formed by the same general laws of soil formation as in the watersheds. However, synchronization of processes of soil formation and deposition of loose material – alluvium is a peculiarity of the formation of floodplain soils [3, 4].

The alluvial deposits brought to the flood plain with flood and affluent waters are characterized with bedding. In the context of the conservation of natural terrains that warpage is gradually processed in soil-forming process. This eliminates the typical layering of sediments and good humus soil is formed on the floodplain. Some researchers [4] found that within the East European Plain during the Holocene (the last 1,5 thousand years) occurred seven stages of soil formation (450-150, 1050-2300, 2800-4200, 4700-6200, 6600-7700, 8300-9500 and 10200-10400). The formation of soil occurred in different (dry and wet) climate phases. Stages of erosive material accumulation flowing between the soil-forming stages are associated with increased humidity of warm and cold periods of the Holocene. The majority of scientists [5, 6, 7, 8; et al.] note that the increase in the amplitude of floods, water saturation with suspended and bed sediments, as well as their accumulation in floodplain terraces are associated with agronomic and other human activities.

The aim of our research - identifying the specifics of the structure of the soil in the bottoms of the valleys of the small rivers in connection with the regime of anthropogenic transformation of terrain in watersheds of the Middle Volga. The study of soil-forming processes is particularly significant in the valleys of small rivers, as they are characterized with fairly uniform climatic, geological and morphological and other natural conditions. This makes it possible to trace the influence of various factors on hydrological characteristics of small streams.

METHOD OF RESEARCH AND STARTING MATERIAL

Field studies that were conducted on the territory of the Middle Volga region (the southern part of the Viatka-Kama interfluve till the basin of the Medveditsa river) from 1983 and over the past 30 years served as the basis for the study of buried soils and warpage in small river basins. In this region more than 150 sections of floodplain sediments of small rivers have been studied. The study of soil genesis was carried out using the conventional method, according to which all the morphological characteristics and soil type were determined [2]. Radiocarbon and spore-pollen analyzes allowed to determine the age of the various layers of soil profiles and species composition of vegetation, typical for each of the periods of development. Radiocarbon datings of wood, peat or humus for 12 cuts were made at the Kiev Institute of Geological Sciences of Ukraine (KIGN) [9]. Youth of buried upper floodplain soils was determined with indicator techniques. Evidence of relatively short time of its existence were archaeological, biological and paleogeographic facts. In the study of the extent of forest vegetation and anthropogenic transformation of river basins large-scale topographic maps of the 70-ies of the XIX century, the 40-80-ies of XX century, as well as aerial photographs were used.

THE RESULTS OF RESEARCH

Since the 16th century, the forested areas of the studied forest zones of the Middle Volga reduced by 2-2.5 times, and the forest-steppe - by 3-4 times. Currently field-forest and field terrains in the Middle Volga occupy two thirds of the territory. Such a strong conversion of natural terrains affected the river flow regime, the state of the river network, as well as the nature and intensity of erosion and accumulation processes in the river valleys.

In the forest zone forest terrains range from 70% or more, and are characterized by internal zoning. In the northern part of the Middle Volga in the subzone of the southern taiga zone and coniferous-deciduous forests formation of pine and spruce forests, and subformations of pine and spruce, pine-broadleaved, broadleaved-spruce and spruce-fir-broad-leaved forests are widespread. Due to the strong violation of

indigenous vegetation such types of forests as limeleaf fir-groves, scrub pineries, sedge birch forests, grassy lime groves and sedge aspen forests are most prevalent here [10].

In the central part of the Middle Volga region in the zone of deciduous forests and forest-steppe zone hardwoods are spread. The forest vegetation is formed with typical indigenous lime, oak and oak-lime formations and subformations and also with their derivatives. At the same lime oak forests, grassy lime groves and sedge birch forests - types of forests, which occupy large areas. On the steep banks of the rivers one can meet azonal fragments of pine forests. Forest and field terrains are notable for low forest coverage from 30 to 70%, the development of meadow-steppe and steppe vegetation with areas of forest ecosystems. Specificity of field terrains, common in the south of the studied area is defined by a large area of development (70%), at the same time virgin vegetation remained at less than 30% of the territory [11]. Agrocultural areas to some degree are present in all natural zones of the Middle Volga.

In small river basins with irregular but relatively overregulated liquid effluent (on the example of taiga zone) normal floodplain soils, similar to the zonal soils of watersheds, according to the definition of E.V. Shantser [12], develop. These soils are characterized by the presence of well-formed horizons (humus, transitional eluvial and illuvial) and the parent rock. The roof of this section is crowned by well-developed zonal soils.

Table 1: The buried soils in the flood plains of small rivers alluvium Middle Volga

River (basin)	Buried soil			Age according to radiocarbon analysis, years (sample)	Holocene climatic periods
	Upper	Medium	Lower		
Lesser Cheremshan (Big Cheremshan)				1195±60 1. (KIGN -619)	subatlantic
stream Temev (Mesha)				1760±65 2. (KIGN -181)	subatlantic
Knya (Vyatka)				1900±90 3. (KIGN -185)	subatlantic
Vala (Kilmez)				2370±70 4. (KIGN -234)	subatlantic
Kosa (Cheptsa)				1370±25 5. (KIGN -615)	subatlantic
Nurminka (Vyatka)				3060±35 6. (KIGN -365)	subboreal
Kolunets (Ulema)				3150±95 7. (KIGN -362)	subboreal
Morkvashka (Volga)				3380±30 8. (KIGN -567)	subboreal
Bizya (Ulema)				3870±40 9. (KIGN -362)	subboreal
Bizya (Ulema)				6780±70 10. (KIGN-363)	atlantic

Our research has shown that in most of the studied sections of floodplains there are several (up to 3) well-developed buried soils (Table. 1). So in the floodplain of river Bizya lower buried soil, the depth of which is 3.5 m from the surface, has an age - 6780 ± 70 years (10). Above at a depth of about 1.8 m from the surface a well-preserved floodplain soil horizon with age of 3870 ± 40 years lies (9). The depth and formation time of

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similar buried soils in the floodplains of other rivers varies within the following limits: on the river Kolunets - at a depth of 2 m, age 3150 ± 95 years (7); on the river Nurminka - at a depth of 2 m, its age of 3060 ± 35 (6); on the river Morkvashka buried soil is located at a depth of 2.1m, its age makes up 3380 ± 30 years (8). These data correlate well with the age of the buried floodplain soils of rivers Volga and Oka studied by A.L. Alexandrovskiy [1] using radiocarbon dates and archaeological data.

The age of upper buried soils according to radiocarbon analysis is within the limits of 1200 to 2400 years (Table. 1). In particular, on the stream Temeva, the left tributary of river Meshi, the upper soil lies at the depth of 1,3m, its age amounts to 1.76 thousand ± 65 years (2); in the floodplain of river Vala - at the depth of 1,2m, its age makes up 2 370 ± 70 years (4).

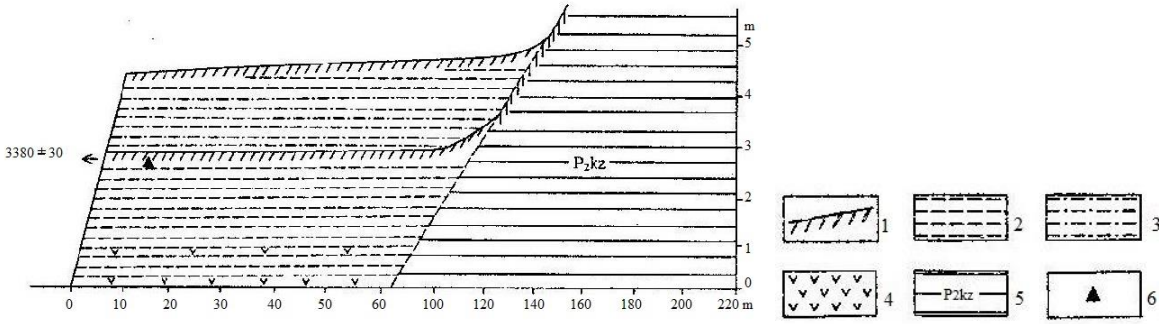

Figure 1: Section of the first over-floodplain terrace of the river Morkvashki (right tributary of the river Volga). Symbols: 1 - the soil, 2 - loam, 3 - sandy loam, 4 - ferrugination 5 - source rock, 6 - samples for radiocarbon dating.

The data of the spore-pollen analysis on the river Kolunets (Fig. 2) indicate the prevalence of forests formed with pine and broadleaf species in vegetation in subboreal period. According to palynological studies broadleaf species pollen share along the whole soil section is quite high and makes up 20-50%.

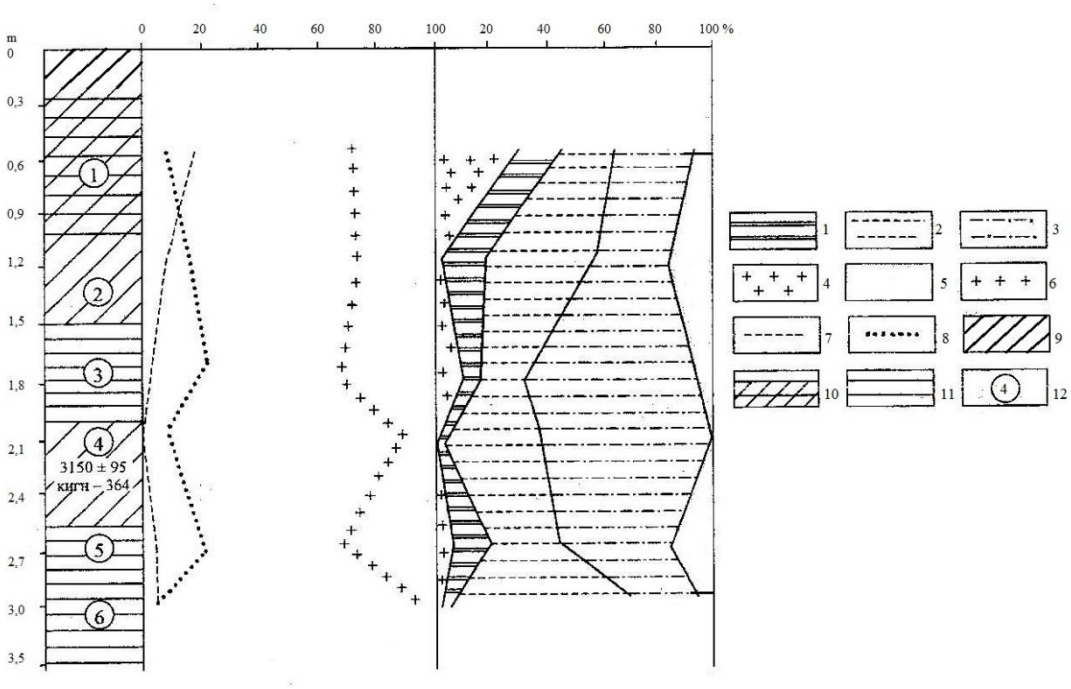

Figure 2: The spore-pollen diagram of floodplain section of the river Kolunets (basin of the river Sviyaga). Symbols. Pollen of breeds: 1 - conifer, 2 - small-leaved, 3 - deciduous, 4 - Pine, 5 - the bushes and shrubs, 6 - all woods; 7 - grass pollen; 8 – pollen of the sporous; 9 - soil 10 - warpage 11 - alluvium, 12 - numbers of samples for the spore-pollen analysis.

Periods of buried soils creation coincide with certain climatic stages of Holocene [1.13]. Thus soils, the age of which is within the interval of 6-7 thousand years ago, as, for e.g. on river Bizya (10), correspond to the

Atlantic period (Table. 1). In this period under the influence of favorable climatic conditions and the development of highly productive vegetation dark-colored soils with a peaty soil profile are formed.

At the same time, the alternation of wet and drier periods in the Holocene subboreal period leads to the formation of a warpage layer on the Atlantic soil. Such warpage was found in the composition of the soil profile at the river Bizya whose thickness reaches 1.5 m. At the end of subboreal about 3,5-2,5 thousand years ago, a new horizon of well-developed floodplain soils, whose age ranges from 3870 to 3060 years, for example, on the river Morkvashka (Fig. 1) appeared. These soils were formed in the more arid climate than Atlantic, under the prevalent at that time pine-deciduous forests. These buried soils have comparatively less humus content, their colour in the area of study is gray, dark gray with reddish and brown shades.

The period of the formation of modern floodplain soils with warpage coincides with the Sub-Atlantic period of the Holocene (Table. 1). The upper buried soil of floodplain of the river Kolunets lies at a depth of 1 m and has an age of about 2000 thousand years. It is separated from the surface with a layer of warpage and underdeveloped floodplain soils. Subatlantic period is characterized by cooling, humidification of climate and development of medium-productive forests, as part of which increases the share of small-leaved and coniferous species, but deciduous reduced participation (Fig. 2). Later in the late subatlantic period (from 1 thousand years ago to the present time) the apparent climate and vegetation cover change were not observed. Modern floodplain soils are characterized by weak stratification and have low coverage of 6-12 cm.

At the top of the buried soil in almost all sections there is warpage characterized by pronounced stratification. Radiocarbon datings from this layer indicate that it was formed in the recent past (Table. 2).

Table 2: Radiocarbon dating of the floodplain warpage of small rivers of the Middle Volga

River (basin)	Warpage capacity, m	Dating object	Depth of the sample, m	Age, years (sample)
Vala (Kilmez)	0,69	wood	0,4	<30 11. (KIGN-229)
Knya (Vyatka)	1,7	wood	1,35	105±80 12. (KIGN -619)
Bakhta (Kama)	4	wood wood	1,9 3,86	60±150 13. (KIGN -234) 150±60 14. (KIGN -233)
stream Temev (Mesha)	2,7	wood wood	1,3 1,6	590±50 15. (KIGN -184) 670±55 16. (KIGN -182)

A sample from the warpage middle layer at a depth of 0.4 m with total capacity of about 0.7m in the floodplain of the river Vala has an age of about 30 years (11). On the floodplain of the river Bakhty power of warpage makes up 4 m, sample from the depth of 1.9 m has age within 60 years (13). Age of warpage sample from the stream Temeva at the depth of 1.3m makes up about 600 years (15).

In addition to radiocarbon dates we have other facts that indicate small age of buried soil top. So, archaeological studies have shown that in the sediments overlying alluvial soil, pieces of pottery (river Bormotovka, basin of the river Yaran) leather shoes (river Nurminka, basin of the river Vyatka), as well as fragments of red brick, remnants of branches, leaves and other organic matter are sometimes found. According to the biological data old trees often have root neck in the humus horizon of upper buried soil, and the lower part of their trunk is washed with different capacity of warpage (river Ulema, basin of the river Volga). In the outcrops of floodplains one can see a shift of buried soil to modern soil of slopes and watersheds (on the developed field and field-forest terrains) as on the river Cheremshan (basin of the Volga), on the river Knya (river basin of the Vyatka), which is a paleogeographic evidence regarding the short time of its development.

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CONCLUSIONS

Thus, in the floodplains of small rivers of the Middle Volga region, there are up to 3 buried soils. Formation of the lower buried soil at the depth of 3.5 m older than 6800 years, coincides with Atlantic period, during which the vegetation was highly productive. The development of the second buried soil at the depth of 1.8 m from the surface 3-4 thousand years old happened during subboreal period of Holocene, which is characterized by the predominance of pine and deciduous vegetation. The uppermost buried soil 1200-2400 years old at the depth of about 1 m, formed during subatlantic period and at that time small-leaved forests dominated. Above the buried soil in the last 600 years or less floodplain warpage has been formed. This period coincides with the intensive agricultural development of the territory. Deforestation and plowing facilitated fast increase of sediment runoff, resulting in accumulation of material on the floodplain of small river basins increase, and the rate of soil formation started to lag behind the rate of accumulation. A human impact in the modern historical period was comparable to the global climate changes during the Holocene. Therefore, buried soils in the flood plains of small rivers can be considered as reference points that show the stages of climate change in the Holocene and the extent of human economic impact on the terrain.

SUMMARY

Holocene buried soils, whose age obtained by the radiocarbon method, make it possible to track the accumulation of floodplain alluvium and stabilization in its accumulation that is connected with climatic periods (atlantic, subboreal, subatlantic). Increased accumulation on floodplains and lower terraces of the small rivers of modern warpage (alluvium) from 600 years ago till the present time, which is determined with the help of archaeological, historical and biological data, is due to the economic development of watersheds and erosion-accumulative processes. Similar phenomena of buried soils in Holocene are characteristic for the east of the Russian Plain, as well as for Central and Western Europe, the southern United States and other regions [3, 6, 7, 8].

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