SOILS OF SMALL ARCHAEOLOGICAL SETTLEMENTS IN THE STEPPE ZONE AS A RESULT OF BRONZE AGE ANTHROPOGENIC IMPACT

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ABSTRACT

The contemporary direction of natural pedogenesis/soil science is ancient anthropogenic impact and climate fluctuations changes. A large number of settlements in the river valleys are unique objects with a long history of development and modern soil cover formation. We studied the soil between the dwellings for a small settlement ***Zarya*** of the Bronze Age. The settlement was part of the economic zone of cattle breeding (horses and cows and sheep) of the large early Bronze Age fortified city Sarym-Sakla, one of the country's Proto-Iranian Cities of the Trans-Ural Plateau. The activity of ancient societies changed the terrestrial ecosystem functioning at macro and microscales. Increased heterogeneity of microrelief forms led to the diversity of soil cover. We found the unusual soil types on microelevations and microdepressions. The enrichment of the cultural layer with phosphorus compounds was revealed, and the hypothesis of the formation of a "reverse" ratio of chernozems-solonetzes of the soil cover of the low above-floodplain terrace as a consequence of several stages of ancient anthropogenic pressure and climatic aridization was confirmed in this area.

We focused on the determination of organic carbon content, magnetic susceptibility, salt composition, cation exchange capacity, and the distribution of mobile phosphates along the soil profile as possible indicators of ancient anthropogenic influence.

The degree of soil properties changes during the anthropogenic impact is commensurate with their transformation in the natural evolution of centuries and even several millennia. Past anthropogenic changes leave a mark in the history of the development of the soil cover predetermining the modern danger of the degradation phenomena.

Moreover, we draw parallels in the history of ecosystems formation and outlined tasks for further research.

Keywords: *overgrazing, unfortified settlements, paleoclimate, steppe, Bronze Age.*

INTRODUCTION

Recording and accurate dating of paleo-processes traces in modern ecosystems can act as a key for understanding the current state and interpreting the history of landscape development, which has numerous and multifactorial confirmations of long-term economic development for the steppe zone in Russia [2], [12]. The stratigraphy of the layers of little archaeological sites provides a possibility to link paleo-solonets traces to certain periods and archaeologically date the enclosing context.

The natural horizons of soils that disappeared under the influence of an ancient anthropogenic factor were replaced by stable pedosedimentary natural-anthropogenic formations – cultural layers. The anthropogenic pressure led to destruct the natural horizons of soils, which than were replaced by stable pedosedimentary natural-anthropogenic formations – cultural layers. The cultural layer consists of artifacts and placeholder. The aggregate is usually formed from the material of the initial soil with an admixture of remnants of construction and household garbage.

For the cultural layers, the most characteristic feature is the increased content of humus and phosphorus [1], [3], [6], [8], [10], the simultaneous increase of which is their diagnostic sign.

The profile distribution of phosphorus in soils with a cultural layer reflects the enrichment of cultural layers with mobile forms of phosphates. During the mineralization of organic matter entering the soil, phosphorus is fixed in the form of hardly soluble calcium phosphates, which persist for hundreds and thousands years. Anomalous zones or layers of concentration of this element are formed. Within the area of ancient settlements, significant fluctuations in the content of phosphates in the soil have long been noted [4], which is explained by the heterogeneity of the settlement of individual parts of the settlements. The use of the phosphate method in archaeological fieldwork to establish the sites of ancient settlements [13], as well as to clarify the details of excavations [11] , can significantly reduce the amount of exploration work.

OBJECTS AND METHODS

The investigated territories are located in the steppe zone on the eastern slope of the Ural mountainous country within the Trans-Ural plateau (200-500 m above sea level) - a peneplain formed as a result of the destruction of the ancient mountain system. The geographical position makes the main feature of the climate continentality with significant daily and annual temperature ranges. In the warm season, about 70% of the annual precipitation falls in the steppe region. At the same time, there is often an influx of continental tropical air from Central Asia, accompanied by the establishment of particularly hot and dry weather. The prevalence of low-cloud anticyclonic weather during the year results in a significant duration of sunshine. The number of hours of sunshine per year in the steppes beyond the Urals reaches 2100-2300, while in the steppes, for example, in Ukraine, - 1800-1900. In terms of thermal resources, the Trans-Ural steppes are closer to the Asian ones than to the steppes of the Eurasian part of Russia. The amount of atmospheric precipitation is up to 250-300 mm in the steppe zone (the long-term average is 330 mm). The climate of the study area is sharply continental with little snow and cold winters, dry and hot summers. Average annual temperatures fluctuate between 1.1-2.6°C, the sum of positive temperatures above 5°C is equal to 2460°C, the sum of average daily temperatures above 10°C is 1950-2300°, the frost-free period lasts about 120 days, the average duration the growing season is 170 days, 250-330 mm of precipitation falls per year, of which 45% in summer and 12% in winter, and only 130-180 mm during the growing season. The character of summer precipitation is predominantly stormy. In low-cloud weather, the soil heats up strongly (up to 65°C), and is exposed to dry winds (up to 30 m/s). The annual evaporation rate is 1.5-2 times higher than the annual precipitation. The depth of soil freezing is 80-200 cm, depending on the particle size distribution. During the spring snowmelt, water is not absorbed into the thawed soil, but flows down its surface. Dry years give way to years with excess rainfall.

In the valley of the river Zingeyka (left tributary of the Ural River, Kizilsky District, Chelyabinsk Region), the settlements Zarya XI (2.5 km south-west of the Zarya settlement, archaeologist F.N.Petrov), Lebyazhye VI (5 km to northeast of the Katsbakhsky settlement, archaeologist L.Yu. Petrova). The settlements are located on the first terrace above the floodplain. The demarcation of the two bends of the river is a hill, in the southern part of which (260 m from the village of Zarya) is the Lebyazhye menhir. In one of the river bends there is the Lebyazhye settlement, in the neighboring one - the Zarya settlement. The direct distance between the centers of the settlements is 720 m. Both settlements are located in close proximity to the fortified settlement of Sarym-Sakly - one of the most striking monuments of the "Country of Cities", and represent an unfortified settlement area.

The granulometric composition of soils was determined according to Kachinsky, the organic carbon content according to Tyurin, mobile phosphorus for saline steppe soils was determined according to Machigin, magnetic susceptibility using a KT-5 device, and other analyzes according to generally accepted methods.

RESULTS AND DISCUSSIONS

The excavation of the Zarya settlement (single-layer character) was laid in the inter-dwelling space. The ceramic complex is identified as Alakul, with pronounced early Alakul features. The state of plant communities at the sites and the adjacent territory is good, since the area of the projective cover is not less than 70% in all cases, the communities are at 1-2 stages of pasture digression, and the associations are mainly herb-grasses. Within the two settlements, 15 sections were laid. The position of the settlements in the immediate vicinity of the river, at an absolute height of 360 m above sea level, at the level of the first above-floodplain terraces with a close (2-3 m) groundwater occurrence suggests hydromorphism as a feature that determines the external appearance of the studied soils.

The soils of the Zarya XI settlement are formed on a binomial: the lower part of the section is heavy loamy-clayey, the upper one is represented by light loams. The Zarya-11-00 cross-section was laid in place of a pit with a humus filling. The humus horizon is heterogeneous, subdivided into non-boiling A1 layer and boiling part - A1* layer , the total thickness varies from 30 to 70 cm, the transition boundary to the B_{CA} is lingual. On the cultural layer containing many artifacts, A1 of low thickness was formed - in total with A_D horison reaching 10 cm.The thickness of the underlying cultural layer reaches 20-25 cm.The B_{CA} horizon under the cultural layer is powerful - 55 cm, and decreases under the filling of the pit. The BC horizons of both sections are similar; they are characterized by the presence of numerous rusty ferruginous nodules, 2-3 mm in diameter. In the walls of the excavation site (Fig. 31), the thickness (A_D + A_1) layers also does not exceed 10 cm, the thickness of the ashpit cultural layer varies from 10 to 40 cm, the calcined cultural layer- 10-12 cm. The total thickness of natural anthropogenic layers, in including those covered by soil formation, mainly fluctuates within 30-40 cm, in some cases increasing to 70 cm.

The granulometric composition of the soils of the sites reflects their formation on a binomial - the lower part is heavier - medium-heavy loam, while in the upper part of the soil - a lightening of the granulometric composition in all cases to light loam, in the background soil to sandy loam, but this is explained by the formation of a suprasaline horizon.

While the strata of the cultural layer acted as a parent rock, the light loamy composition remains a marker of the boundaries of the distribution of cultural layers as the most conservative soil property. Accordingly, the “background” soils of the settlement are actually not such, but are located on the outskirts of the settlement, where there are no longer artifacts, but an anthropogenically transformed layer is present. Moreover, the complexity of the cover, inherent in the first terraces above the floodplain in this region, is formed regardless of the presence of the cultural layer.

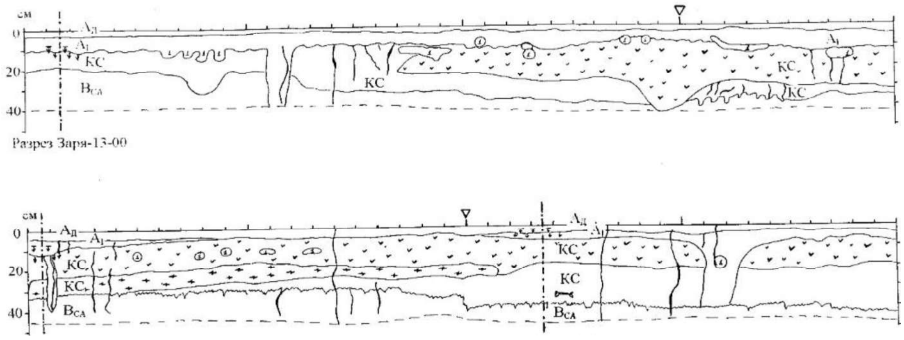

Fig. 1. *Stratigraphy of layers and soil sections of the eastern cross-section of the ancient settlement of Zarya in the South Urals. The cultural layer is designated «KC». Layer diagnostics scheme is made by the author.*

The humus content in the sod and A1 horizon of the settlement and in the background soil of the is higher than 10%, which indicates the formation of chernozem-meadow soil. In the soil of the background microdepression, the humus content reaches 5%. The large drop (decrease by 4 times) in the humus content from 10.08% in the A1 horizon to 2.56% in "A1" is explained by the presence of natural-anthropogenic sediment in the upper part of the section, enriched with organic matter. With depth, the humus content gradually decreases, in horizons B, BC it varies from 0.49 to 0.75%. New formations of carbonates are represented by impregnating forms. Carbonate profile of background soils with one maximum. In the soil of the microdepression, it is located at a depth of 50-70 cm (16.4%), and at a depth of 30-40 cm in the soil of the microdepression (20.8%). At the settlement, an increase (by a factor of 2) is noted in the $CaCO_3$ content in the ashpit cultural layer (from 4.6% in the A1 horizon to 10.8% in the cultural layer). The increased content of carbonates in the cultural layer is probably determined not only by the enrichment of the layer with ash, but also by the introduction of carbonate-containing rocks in the process of economic or ritual activities of the population. Deeper is again a decrease in the content of CaCO3 in the first buried soil (up to 6%), again an increase (almost 3 times) in AB_{CA} to 20.6%, and a gradual decrease with depth - up to 13%; The absence of a humus peak in [A] 50-60 cm suggests a humus filling of the dwelling cavity.

The maximum gypsum content (0.31% in the background rise, horizon "B_{CA}", 0.45% in the background microdepression, horizon B_{CA}) coincides in depth with the horizons of maximum carbonate content. At the settlement, gypsum is 2 times more (0.65%). The reaction of the medium in the soil of microelevation (background 1) is neutral in the upper part (pH 7.0 - A_D, A1 layers), in the lower part it is alkaline (pH 9.2-9.1) In background 2 (microdepression) it is alkaline (from 8.0 to 9.2). In the soil of the settlement, the reaction of the solution lies in the alkaline region - from 8.0 to 9.5 in the lower part of the profile. The acidic reaction of soil solutions favours the dissolution of bases, including bones, and the transition of mineral compounds to a mobile state. The established reaction of the cultural layer is alkaline (pH 9.0), which contributes to the preservation of artifacts. The composition of the salts according to the results of the analysis of the water extract is as follows. The soil of the rise (background 1) is slightly saline (the sum of salts does not exceed 0.1%), the salinity is predominantly hydrocarbonate-magnesium, in the soil of the microdepression (background 2) the sum of salts varies from 0.2 to 0.5%, in the lower horizons the salinity is sulfate-chloride-sodium, in AB_{SL} layer sodium bicarbonate. The composition of exchangeable cations is dominated by magnesium, the sodium content in the mountains. AB_{SL}, B_{CA} is 21-22% of the catonic exchange capacity. At the settlement in the soil buried under the cultural layer, the sum of salts is 0.27-0.60%, with a maximum in [AB_{SI}]. In the cultural layer itself, the sum of salts is 0.13%, the lowest salinity in A1 is 0.07%. the type of salinity in the lower horizons is chloride-sulphate-sodium, in the filling of the dwelling depression it is predominantly sulphate-magnesium, in the cultural layer it is chloride-hydrocarbonate-calcium, above it is hydrocarbonate-magnesium-calcium.

The amount of oxides in the backgrounds is comparable, the maxima are at a depth of 80-100 cm (0.56, 0.41 for Al_2O_3; 0.43, 0.34 for Fe_2O_3, respectively). In the sod of the settlement, the content of Al_2O_3 is increased (0.7%), in the cultural layer - 0.6%, and in [A] layer - 0.4%. The maximum of mobile forms of Fe_2O_3 in terms of values is comparable to the maximums of backgrounds, but it is located higher - at a depth of 0-20 cm, their highest content is characteristic of the cultural layer. The distribution of potassium content in background soils is biogenic with a maximum in the upper horizons (78-96 meq / 100 g of soil). The concentration of potassium compounds is high. In the soil of the settlement, the values increase in comparison with the background by 2 times (144-200 meq / 100 g of soil - A_D and cultural layer). The general appearance of the curves is similar in the backgrounds and at the settlement - a smooth decrease with depth, but at the settlement the values are increased by 7-10 times (12-20 mEq / 100 g of soil in the lower horizons of the backgrounds and 100-140 mEq / 100 g soil in the settlement), which gives grounds to speak of the introduction of organic substances (economic or ritual activities) into the cultural layer of the settlement and the substrate that filled the dwelling cavity.

The distribution of phosphorus compounds in the backgrounds of the settlement, as well as potassium, is biogenic in nature - the maxima are in AB (background 1, 3.6 meq / 100 g of soil), A_1A_2 layer (background 2, 2.8 meq / 100 g of soil). The second maximum in both backgrounds falls on B_{CA} and is 2.0 meq / 100 g of soil. The minimum in the microelevation falls on horizons buried under sediment. The values are 0.7 mg-eq / 100 g of soil; in the microdepression, on AB_{SL}, the values are 1.4 mg-eq / 100 g of soil. In general, the values are of the same order of magnitude. At the settlement, close to the background (maximum) values only in the BC mineral horizon (90-100 cm) - 2.4 mg-eq / 100 g of soil. The greatest difference in comparison with the background is characteristic of the 40-50 cm AB_{CA} horizon - 10.7 meq / 100 g of soil - the greatest "use" of the layer, the greatest enrichment of it with organic substances. The increased values at a depth of about one meter can be explained by diagenetic intraprofile redistribution. The course of the profile distribution curve does not correspond to the background one, and rather has the opposite form, which is associated with anthropogenic impact. The maximum content of mobile phosphorus in AB_{CA} can be interpreted in accordance with natural processes. In the backgrounds, the maximum also falls on the B_{CA}.

At the Zarya settlement, the magnetic susceptibility of the underlying rocks is significantly lower (16 units) than at Lebyazhye (70-125 units - BC horizons), located nearby. The minimum values are typical for the B_{CA} horizons (or cultural layer with calcium); the maxima - for the humus-rich horizons, both for the buried and the modern ones - 170-187 units for Lebyazhy, 48-66 units for Zarya.

The study of the microbiological characteristics of ancient soils is actively developing today, both buried under embankments and cultural layers [5, 6, 7, 14, 15]. It is necessary to continue the study of ancient small settlements of cattle-breeding specialization in the direction of studying the enzymatic and microbiological activity of soils.

The characteristic features of the soils of the depressions are low thickness (up to 10 cm), low humus content (2.44%) of the upper horizon in comparison with the soils of elevations, for which the average thickness of the humus horizon is 80 cm, and the amount of humus in the upper part reaches 6% and very decreases smoothly with depth up to 1.5-0.2%. The residual-granular residual-coprolite structure of the humus horizon of the soils of micro-elevations at a depth of 50-70 cm was noted, which indicates a well-developed chernozem-meadow soil of this area in ancient times, before the beginning of anthropogenic pressure.

It is characteristic that in the immediate vicinity of the fortified cult and production centres of Sarym-Sakly and Arkaim of the Chelyabinsk region of the Russian Federation, there was no reverse complexity, while at a distance of 1 km there were small unfortified satellite settlements of ancient pastoralists, in the vicinity of which soil pits many times the reverse complexity is fixed. This made it possible to assume that the cause of the inversion complexity of the soil and vegetation cover is overgrazing in antiquity [9].

The first stage of overgrazing took place in the Late Bronze Age. It was during this period, no later than the middle of the 2nd millennium BC, that the first violations of the natural confinement of the soil and vegetation cover to the elements of the microrelief occurred. This conclusion is confirmed by the close confinement of the identified inversion soil-plant associations to the vicinity of the monuments of the Late Bronze Age and the almost complete absence of stationary settlements in this area in the subsequent period [10]. Aridization of the climate in the 1st millennium BC (the early Iron Age) allowed the prevailing inverse relationships to gain a foothold, and widespread grazing at a later time contributed to their maintenance.

CONCLUSION

In all cases, the formation of complexes of chernozem-meadow soil and solonetzes takes place, both in the vicinity of the monuments and in the settlements themselves, with the only difference that anthropogenically transformed layers act as the parent rock in the settlements. In our study sites, the formation of complexes of chernozem-meadow soil and solonetzes takes place, both in the vicinity of the monuments and in the settlements themselves. The difference is anthropogenically transformed layers act as the parent rock in the settlements In general, soil formation proceeds according to the chernozem-meadow type, which is characteristic of the soils of the corresponding above-floodplain river terraces in the vicinity. The soil formation proceeds according to the chernozem-meadow type, which is usual of the soils of the above-floodplain river terraces in the area of paleo settlements.

The soils of ancient settlements are formed under the joint influence of natural and anthropogenic factors, and are special formations, since their normal development is interrupted by anthropogenic impact and the growth of natural-anthropogenic sediments. The soils of ancient settlements are formed simultaneously of natural and anthropogenic factors. These soils are special formations, since their normal evolution is interrupted by the anthropogenic impact and the growth of natural-anthropogenic sediments.

The thickness of the soils of the ancient settlements ranges from 20 to 150 cm. The sediment includes the last stage of soil formation, which covered 10-18 cm, and the ashy cultural layer, which was unaffected by soil formation. The ash pan usually has a thickness of 20-30 cm, sometimes it is subdivided into “ash pan” and “calcined”, the latter has a slightly more brownish tint in comparison with the ash pan, but mostly the same properties.

The features of the cultural layers are light granulometric composition, low density, morphological heterogeneity. The cultural layer is characterized by an increase in the content of humus and phosphorus, high carbonate content, alkalinity, low salinity, and low values of magnetic susceptibility.

Overgrazing and the associated degradation of the vegetation cover, including the subsequent erosion of soils, caused the development of combinations of soil-vegetation cover and microrelief, which are typical for the steppe region. The revealed examples of the development of saline soils in microdepressions and zonal soils on microelevations were found only in a kilometer zone in the vicinity of numerous large settlements of the Late Bronze Age.

It should be noted that there is a clear lack of information about the influence of ancient cattle breeding on steppe soils, and especially on the soils of steppe river valleys. Taking into account that in the steppe zone, almost all archaeological sites are confined to river valleys, the importance of studying this issue increases even more.

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