

Reconstruction of the Ecological Condition of Bronze Age Civilization to the Border of Europe and Asia, Russia

Valentina Prikhodko^A, Igor Ivanov^A, Ol'ga Khokhlova^A, Dmitry Manakhov^B

^AInstitute of Physicochemical and Biological Problems in Soil Science of Russia Academy of Science, Pushchino, Russia, Email valprikhodko@rambler.ru

^BFaculty of Soil Science, Moscow state University by M.V. Lomonosov, Moscow, Russia, Email demian2@yandex.ru

Abstract

In 1987 in the Chelyabinsk region Russia a fortified settlement of the Bronze Age was found, called the Arcaim. Nowadays near it 22 ancient settlements and thousands of archaeological monuments were opened along the Ural Mountains. This suggests that an ancient civilization was on the border between Europe and Asia at the turn of III and II Millennia BC. New radiocarbon dating of paleosols humus was received. On the base of our investigation we can distinguish stages of soil formation in the Trans-Uralian region during the last 4000 years. Research of paleosols buried under bank-walls and mounds showed that the soils have the more shallow profile, greater carbonate horizon thickness, less humus content, more pronounced features of solonchekity and salinity degree than modern background soils. These features indicate a more arid climate 3900-3000 years ago compared to today's environmental conditions. The stage of 3000-2400 years ago is characterized by progressive climate humidification.

Key Words

Paleosols, steppe, ecological condition, climate reconstruction

Introduction

Authors of several articles during 20 years are conducting a comprehensive scientific work in the Arcaim Reserve and nearby area. In 2009 for the continuation of this work scientists from five universities of Japan were invited. Results of these studies will be published in materials of this congress.

The climate of the region is continental with a dry hot summer and little snow and cold winters. There mainly ordinary chernozems and soloncheks, rarely southern chernozems have formed. Soils often have salinity and alkalinity signs. The objects of study were paleosols buried under the walls and mounds. Field work was conducted in Bredinskiy and Kizil'skiy areas of Chelyabinsk region. Three sites were studied (52° N, 58-60° E) (Figure 1).

1. Paleosols of Arcaim settlement of Bronze Age under the inner and outer walls, constructed 3700 years ago were objects of study. The city diameter makes up 165 m. Bypass ditch and two rings of defensive wooden walls of 7 m height with towers and advanced fortification are well distinguished (Arcaim, 1995; Zdanovich, Batanina, 2007). It is located at the confluence of the Big Karaganka and Utyaganka rivers. Height of the earthen walls is 0.7 and 1.4 m.
2. Paleosols of four mounds which were built 3900, 3500, 3000, 2300 years ago near the Aleksandrovskii village in the Big Karaganka river valley were investigated.
3. Big Syntashta mound, which is part of the historical complex, localized at 4 km from the village Rymnitsky on the first floodplain terrace of the Syntashta river was studied. The mound was excavated in 1971-76 (Gening *et al.*, 1992). From previous excavations two walls remained.

Methods

Soil properties were determined by standard methods: particle size distribution - pyrophosphate method, the content of humus - by Tyurin method, carbonates - acidimetric method, gypsum - gravimetric method, content and composition of easily soluble soils - by Arinushkina method and exchangeable cations content - by Pfeiffer method (Arinushkina, 1970).

Reconstruction of environmental conditions of past eras is done through a comparison of the properties of buried paleosols and modern background soils.

The contact between the mound and the buried soil is very distinctive. It is marked by a bleached layer that developed at the place of the former sod (AO) horizon. Diagenetic changes in the upper horizon of buried soils are manifested by a certain decrease in the humus content because of its mineralization and the absence of the input of fresh plant residuals. It has been shown earlier that the humus horizon of the soils buried 2000-4000 years ago retains about 40% of the initial amount of humus (Ivanov, 1992).

Radiocarbon dating of humus from the upper 5 cm layer of paleosols were done in the Kyiv Radiocarbon

laboratory. For determination of the radiocarbon dating of paleosol humus for data of mounds building and soil burring respectively we used the approach (Chichagova, 1985; Alexandrovskiy *et al.*, 1996). According this method "own" age of humus of upper 5 cm of stepper chernozems varies from 300 to 500 radiocarbon years. Thus age of humus of paleosols equals radiocarbon age determined with the help of ^{14}C analysis minus 500 years.

Results

Arcaim

The thickness of humus horizon (A + AB) of buried paleosols is less on few cm than in the background-modern day soils. Carbonate horizon was greater in the ancient soils then in background ones. Reconstructed humus content in profile of paleosols is less than the background-modern soils. Alkalinity degree is more pronounced in paleosols and it is accompanied by a higher content of water soluble salts and gypsum. Amount and form of humous tongues in paleosols and background soils do not differ. Nowadays ground water level is near 4 m. Modern soils in the BC horizon have rusty spots of iron oxides. In paleosols these signs are absent suggesting that in ancient time ground water was deeper than at present. Modern soil is chernozem, weakly alkalized and with moderate thickness and the residue of the recent short stage of shallow ground water table. Paleosols characterized as chernozem ordinarily with thin thickness and high and moderate alkalinity and salinity features. Arcaim paleosols have features that suggest greater aridity of the climate compared with today. Atmospheric moisture in the Arcaim era was smaller than at present.



Figure 1. Settlement Arcaim of the Bronze Age from the sky. (photo of Arcaim Reserve archives).



Figure 2. Reconstructed ancient mound.

Syntashta

The height of the Syntashta mound was 4.5 m and diameter - 95 m. Unusually for this mound is the presence of a horizontal layer with thickness of 40 cm. This layer was constructed on the surface of paleosol. This horizontal layer was created from an obliquely arranged soil blocks.

It was as a kind of "step", on top of which different sections of the embankment were created. The embankment of the mound has a complicated construction and consists from alternating layers of soil, sand, wood, bark, etc. On archaeological evidence it date is by boundary of II and III millennium BC.

Parent material has a light loam texture. In the investigated soils at a depth of 1-1.2 m is a plate of cemented sandstone (Mesozoic-Cenozoic basement rocks), relatively solid, and slightly disintegrated.

The morphology and properties of soils at the mound edges and inside are different.

Determining the paleosols age by the radiocarbon method showed that the soil in the central part of the mound was more ancient than at the periphery (Table 1). The older soil compared with younger one has less humus at 6-16 cm, worse structure, more pronounced humus tongues and signs of waterlogging in the form of manganese neof ormations in the upper horizons, and the presence of bluish and brown shades in the lower profile. The older paleosol is meadow chernozemic with signs of overmoistening.

Younger soil, overlying the edge of the mound contains more humus than the more ancient soil. Humus tongues in AB horizon are less pronounced and have a thick base. In the younger paleosol waterlogging signs in the upper horizons are absent, they remain only in the lower horizons, the carbonate horizon had less

thickness with more pronounced CaCO_3 accumulation in the form of white spots. The soil is a meadow chernozemic. The thickness of humus horizon in background soils is greater than in paleosols and ranges from 45 to 60 cm. Modern soils have more humus than the reconstructed humus content of paleosols. The modern background soil is a meadow chernozemic.

Differences of paleosol age under the one Syntashta mound can be explained by two phases of burial monument construction (Khokhlova *et al.*, 2008) or the spread of the mound after its construction. Paleoclimatic conditions of the time of development of both paleosols are characterized by contrast: alternation of humid and dry periods occurred. Arid intervals were expressed more clearly than now. The present time is relatively more humid than at the time of paleosol formation.

Table 1. Radiocarbon dating of Syntashta mound.

Profile	Location	Laboratory number	Soil humus age on the base of ^{14}C	
			BP	BC/AD
P. 4-C-II-09	End of mound	Ki – 16132	3210 ± 70	1σ 1530-1400 BC 2σ 1690-1310 BC
P. C1π/06-2	End of mound	Ki – 13828	3540 ± 90	1σ 1980-1740 BC 2σ 2150-1600 BC
P. 5-C-II-09	Inside of mound	Ki – 13827	4170 ± 140	1σ 2910-2570 BC 2σ 3100-2300 BC
P. C1π/06-1	Inside of mound	Ki – 16134	4110 ± 90	1σ 2870-2800 BC 2σ 2890-2460 BC

Alexandrovskii

On the base of our investigation we can distinguish the following stages of soil formation in the Trans-Uralian region during the last 4000 years (Ivanov, Chernyansky, 1996). In the soil buried 3900-3000 years ago the humus profile thickness and reconstructed humus content in the upper horizon was slightly lower than in the modern soils (by 5 cm and 0.8-1% respectively). Paleosol contains a low CaCO_3 amount (1.3% in the layer 0-1 m). At this period environmental conditions ranged from more arid and continental to those close to the present ones. Aridization developed very gradually and had a cyclic character. The soils of this epoch can be classified as intergrades between ordinary and southern chernozems.

The stage of 3000-2400 years ago characterized by progressive climate humidification.

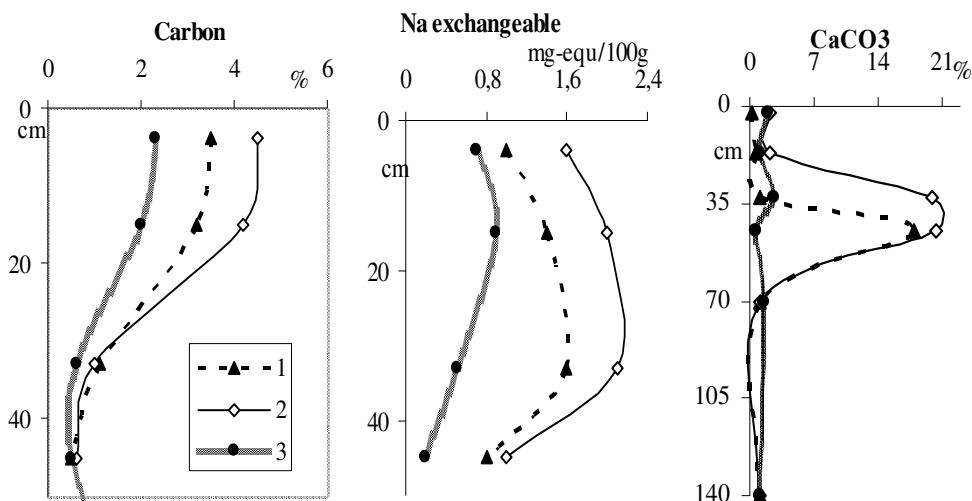


Figure 3. Soil properties of Alexandrovskii plots, 1 - modern soil, paleosols buried years ago: 2 - 2200, 3 - 3900.

The paleosol buried under the mound 2300 years ago is characterized by contradictory properties, such as: high humus content and large alkalinity degree, large carbonate horizon thickness, well-defined humus tongues. These rather controversial soil properties, i.e., the combination of soil features that could develop in arid and in humid conditions within one profile. They can be explained by their nonsimultaneous, successive

origin. High humus concentration could have formed prior to the development of arid pedogenesis, one or two centuries earlier. Before being buried, this humus was still preserved in the soil profile; there was not enough time for it to mineralize in the more arid environment. Judging from the integrity of features one can classify this soil as an ordinary chernozem, intergrading to a southern one.

Conclusion

Nowadays 22 ancient settlements and thousands of archaeological monuments have been opened on the steppe area stretching along the eastern slopes of the Ural Mountains for 300 km. Research on paleosols buried under bank-walls and mounds for few archaeological monuments was carried out. New data on the reconstruction of environmental conditions of the Bronze Age civilization of this area were received. Radiocarbon dating of paleosols humus for mounds and buried soils was done. On the base of our investigation we can distinguish a few stages of soil formation in the Trans-Uralian region during the last 4000 years. Soil features indicate a more arid climate 3900-3000 years ago compared to present environmental conditions. The stage of 3000-2400 years ago is characterized by progressive climate humidification. In the Arcaim Reserve scientists of many specialties work together and, the ancient technologies are studied. On its territory a museum was built, ancient burial mound "Temyr" and Neolithic settlements were reconstructed (Figure 2). 20 thousand tourists visit the Museum-Reserve annually.

Acknowledgements

This work was supported by grant RFBR 09-05-92106- Jp-a

References

- Alexandrovskiy AL, Chichagova OA, Shishlina NI (1996) ^{14}C studies of burial mounds in the steppe zone: chronology and paleoenvironment. In 'Proceedings of the 11th International Workshop on Isotope-Geochemical Research in Baltic region', March 14-16, Lohusalu, Estonia, p. 19.
- Arinushkina EM (1970) Handbook for chemical analysis of soils. M.: Moscow state University, 596.
- Arcaim: Search. Research. Discovery. (Ed. GB Zdanovich). Chelyabinsk: Kamenniy poyas, 1995. 224.
- Chichagova OA (1985) Radiocarbon dating of soil humus. M.: Nauka, 157.
- Ivanov IV (1992) Evolution of the steppe zone soils in the Holocene. Moscow: Nauka, 192.
- Ivanov IV, Chernyansky SS (1996) General regularities of the development of chernozems in Eurasia and evolution of chernozem in the Trans-Uralian region. *Eurasian Soil Science* **29**, 975-983.
- Gening VF, Zdanovich GB, Gening VV (1992) Syntashta. Archaeological monuments of Aryan tribes of the Ural-Kazakh steppes. Chelyabinsk. Vol. 1, 520.
- Khokhlova OS, Khokhlov AA, Gol'eva AA, Zdanovich GB, Malyutina TS (2008) Natural Science Investigation of the Great Syntashta mound in the Chelyabinsk region *Vestnik OSU* **10 (92)**, 150-156.
- Zdanovich GB, Batanina IM (2007) Arcaim – Country of Towns: Space and imagery (Arcaim: levels of investigation). Chelyabinsk: Krokus press, 260.