PALAEOSOILS AND PALAEOENVIRONMENT OF THE URAL STEPPE REGION DURING THE BRONZE AND EARLY IRON AGES

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Introduction

The objects of these investigations were the modern dark-chestnut soils in the Ilek-Khobda valley and palaeosoils buried under archaeological monuments (kurgans) during different periods. The region under study was the South-western rim of the Southern Ural mountains. The dominant heights there are 100–300 m. The relief is mainly hilly plain. In the south-east, strongly inclining slopes with outcrops of rocks occur. The surface is dissected by a network of rivers (Ilec, Khobda), gullies and beams. Climatically the territory belongs to the Atlantic-Continental area, with a mean annual rainfall of 282 mm. The average temperature in July is 28C and in January –10C. The average thickness of frost is 1.30 m. The shift from herb bunchgrass to deserted steppes with southern chernozems, dark-chestnut and chestnut soils is characteristic of this somewhat limited region.

The objects of study were the palaeosoils of 36 kurgans dating back to the Bronze Age (mid–2nd millennium B.C.) and three stages of the Early Iron Age: 6th to 5th centuries B.C. (Savromatian time), 4th to 2nd centuries B.C. (Early Sarmatian time) and 3rd to 4th centuries A.D. (Late Sarmatian time). The obtained data describe the condition of the soil cover roughly 3500, 2500, 2300 and 1700 years ago, i.e. the second half of the sub-boreal and first third of the sub-Atlantic chronozones of the Holocene.

Methods

Generally accepted methods for chronological and soil-archaeological studies were used. The methods have been widely used in the study of soil development. Their possibilities, advantages and restrictions are discussed elsewhere (Alexandrovskiy 1983; Gennadiev 1984; Demkin 1993, Ivanov 1992, Weiss et al. 1993).

With the help of morphological, chemical-analytical and geophysical methods the following soil parameters were investigated: stratigraphy; humus content, carbonates, gypsum, water-soluble salts; morphometry of carbonate formation; magnetic susceptibility etc. From the collected data, the influence of climate on the dynamics of soil formation in the dry steppes of the Southern Urals at various historical periods could be elucidated. Based on these results, information was obtained on the regularity and natural migration of soil carbonates.

Results and discussion

The main morphological and chemical properties of the investigated soils are given in Table 1. They show that soil formation processes in the second half of the sub-boreal and first half of the sub-Atlantic periods can be characterised as highly dynamic in the dry steppes of the Southern Urals. Thus in the 2nd millennium B.C., in a region on the left bank of the river Ilek, chestnut soils were predominant but by the middle of the 1st millennium B.C. had evolved into dark-chestnut soils, the northern boundary of which today is the Ilek valley. Hence between 3500 and 2500 years ago, a southward shift of soil-geographical subzones took place, accompanied by a direct or cyclical shift of genus soil taxa (salinity, humification, alkalinity etc.). During the 2nd to 1st millennium B.C. the soils underwent mainly allo-evolution (Sokolov et al. 1986), in contrast to the auto-evolution or self-development of the last 2000–1500 years. In the second half of the Holocene, soil formation in the Southern Ural dry steppes was similar to that of the soil-climatic facies characteristic to Central Asia. However, a shift of natural borders within the limits of the latter was more significant (Ivanov, 1992). However, in the adjacent Lower Volga region evolutionary shifts of similar scale were noted only in the Precaspian lowlands, where changes from hydromorphic to automorphic conditions of soil formation caused a transition of grassland soils to dry and desert steppe (Demkin 1993). Within the boundaries of raised plains (Syrt, Privolga, Ergeni) chestnut soils did not change their subtype. It should be noted, however, that the major soil parameters of the West and East habitats of the Volga-Ural dry steppes became more similar than during the Bronze Age.

The revealed regularities of periodical variability in soil formation in the Southern Urals were undoubtly caused by environmental factors, primarily climate. Palaeosoils connected with archaeological monuments can therefore be used as indicators of environmental conditions during different periods of the Holocene (Zolotun 1974; Alexandrovskiy 1983; Gennadiev 1984; Demkin & Ivanov 1985; Ivanov 1989; Weiss et al. 1993). The most informative soil parameters for palaeogeographical reconstruction, in particular for the steppe zone, are the content and depth distribution of humus, water-soluble salts, gypsum, carbonates, and degree of alkalinity.

There are fairly numerous palaeosoil and palaeoecological data indicating the subboreal aridisation of climate in the steppe zone of Eurasia in the 3rd and 2nd millenia B.C. (Varshavskii 1962; Zolotun 1974; Alexandrovskiy 1984; Varushchenko et al. 1987; Zubakov 1991; Ivanov 1992; Demkin 1993; Gerasimenko 1994; Pesochina 1994). Different authors give different values for the duration of this period and according to some of them recurrence may have occured. Our investigations in the Predural dry steppe give reason to support the latter point of view. In the middle of the 2nd millennium B.C. palaeosoils of this region were of the chestnut subtype (as distinct from the modern dark-chestnut) characterised by alkalinity, high salinity, carbonate accumulations close to the surface and lime carbonate effervescence. In addition, well expressed tongue-like rims in the bottom half of the humus horizon indicate, to a greater degree, a more continental climate in the Bronze Age compared with the subsequent epoch.

Characteristic changes in the soils of the studied region in the period from Bronze to Savromatian (15th – 5th centuries B.C.) times are: increase of thickness of the humus horizon A1 + B, reduction of its tongue-like rim, increased humification, demineralisation and desolonetzisation. These facts make it possible to speak of milder climatic conditions during the given chrono-interval, probably with some increase of humidity as confirmed by investigations in other regions of the steppe zone of Eurasia (Alexandrovskiy & Birina 1987; Spiridonova 1991; Alexandrovskiy & Chichagova 1994; Gerasimenko 1994; Gol'eva et al. 1994). Within the limits of the territory investigated, the soil transformations resulted in a change from chestnut subtype to dark-chestnut and in the shift of subzones to the south. A number of authors also mention migration of natural borders in the same direction.

Table 1. Morphological and chemical properties of buried and modern soils

Parameters	Bronze Age mid–2nd millenniumB.C.	Early Iron Age 6th–5th centuries B.C.	Early Iron Age 4th–2nd centuries B.C.	Early Iron Age 3rd–4th centuries A.D.	Modern
Number of archaeological monuments	9	7	19	1	–
Thickness of humus horizon A1+B (cm)	22	26	27	29	33
Content of humus in horizon A1(%)	2–3	3–4	3–4	–	2.5–3
Degree of humification	strong	moderate	moderate	moderate	weak
Granulometric composition of soils	loam	loam	loam	loam	loam
Ratio of clay content hor.B/hor. A1	1.3	1.2	1.2	–	1.3
Level of effervescence (cm)	14	27	27	29	33
Depth of carbonate accumulation (cm)	15	30	30	29	34
Content of $CaCO_3$ in layer 0–2 m (%)	9.3	10.6	9.7	–	9.7
Depth of highly water-soluble salt accumulation (cm)	79	154	133	160	>200
Content of highly water-soluble salt in layer 0–2m (%)	0.29	0.12	0.24	–	0.07
Depth of gypsum accumulation (cm)	85	170	152	160	>200
Content of gypsum in layer 0–2 m (%)	0.54	0.04	0.19	–	0.07
Magnetic susceptibility in hor. A1 (n*10–5 SI units)	60	100	85	110	110
Soils	chestnut	dark-chestnut			

For the Sarmatian period (4th century B.C. – 4th century A.D.), variability in a number of soil properties and various trends point to appreciable variations in climatic conditions and, first of all, to the degree of humidification. In the 4th–3rd centuries B.C. aridisation of the landscape (rise in the level of salt and gypsum accumulations, some reorganisation of carbonate profiles, change in the values of magnetic susceptibility) occurred. At the end of the 1st millennium B.C. this gave way to a period of relative increase in precipitation, which resulted a secondary, over the last 1500–2000 years appreciable, demineralisation of soil down to a depth of 2 metres. The short-term aridisation of climate in Early Sarmatian times is seen in palaeosoil, palaeogeographical and archaeological data, and also in other steppes of Eurasia (Varushchenko 1982; Polos'mak & Grebnev 1986; Ivanov 1994).

Information on the condition of soils and landscapes of the steppes of the Southern Urals during the last 1700 years suggests that during this period climatic fluctuations were not great enough to trigger appreciable evolutionary shifts in pedogenesis.

Thus the data obtained from palaeosoils suggest the following chronology of climatic conditions in the studied region from the Early Bronze Age to the present:

- End of 3rd millennium B.C. – first half of 2nd millennium B.C.: increasing continentality and aridisation.
- Second half of 2nd millennium B.C. – first half of 1st millennium B.C.: decreasing continentality with some increase of humidification.
- Second half of 1st millennium B.C.: aridic conditions.
- End of 1st millennium B.C. – first half of 1st millennium A.D.: mild climate with increasing humidity.
- Second half of 1st millennium A.D. – 2nd millennium A.D.: relatively stable conditions.

Taking into account the migration of soil-geographical subzones during the investigated chrono-interval (second half of the Holocene), it is possible to state that fluctuations in atmospheric precipitation ranged from 230 to 300 mm/year. At present this value is 280 mm/year.

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