aged from earlier times in eastern sectors of the continent. The similar time lag, often longer in duration (up to 3–6 centuries), characterizes periods of higher precipitation and river runoff. However, time difference in the completion of humid periods is shorter, if exists. Time lag exists also for climatic events of smaller temporal scale and intensity, but it is shorter in duration.

As a first approximation, eight regions can be discerned in the extratropical Asia and East Europe by the differences in their humidity response to the large-scale global changes in air temperature during the last millennia. The above approach can possibly be useful in long-term predictive studies.

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Abrupt Climatic Change in the Dry Steppe of the Northern Caucasus, Russia, in the Third Millennium BC

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ABSTRACT. The abrupt climatic and environmental changes in the dry steppe zone of the Northern Caucasus, Russia, in the Third millennium BC has been fixed on the basis of the paleosols study in the Big Ipatovsky kurgan. In paleosols separated the main mounds (layers) of the kurgan the small fragments of charcoal occurred. Their dating by AMS measurements showed that two upper paleosols with the most clear evidences of climatic aridization developed in the range of dates from 4000 ± 40 to 4080 ± 40 years BP or about 2450–2650 cal BC.

KEY WORDS: paleosols, Holocene, radiocarbon dating, climate change.

Introduction

The abrupt climatic and environmental changes in the Third millennium BC are evident from the different methods of investigation including the results of archaeological monuments studies (Weiss, 1993; Dalfes et al., 1997; Gerasimenko, 1997). The similar climatic changes have been revealed for the south of the European Russia from the study of paleosols buried under the kurgans (ramparts, burial mounds) of the Bronze Age (Fedoroff et al., 1997).

The big kurgans constructed with long interruptions during which soils have enough time to develop are of great interest to the climatic reconstructions. It can be many such soils in big kurgans; for example, in Big Ipatovsky kurgan it was five soils developed during interruptions of this kurgan construction.

The aim of this paper is to investigate a chronology of climatic changes in the Third millennium BC for the dry steppe zone of the Northern Caucasus, Russia based on AMS dating of soils and mounds in the Big Ipatovsky kurgan.

Methods and material studied

The Big Ipatovsky kurgan (BIK) was allocated at the northern periphery of the Stavropol' upland on the high terrace of the Kalaus River. The height of the BIK was 6.5 m, its construction was very complex. The complex mound of the BIK was constructed by ancient men in the Bronze Age with long interruptions during which the soils developed. In the BIK five paleosols (from lower [1b] to upper [4]) on the different age mounds have been observed. These paleosols were observed not only on the surface of the different mounds but on the slopes, colluvial deposits and ditches of the BIK as well. Besides, one paleosol was buried under the first mound of the BIK and yet another modern soil developed on the surface of the BIK. All together these soils were a vertical chronosequence. In the foundation of the BIK the well-formed paleosol was observed. At the central part of the BIK this paleosol was buried earlier than in its periphery. For this paleosol (it is lie under soil [1b] and have number [0]) the horizontal chronosequence has been revealed: paleosols buried under the first [0–1], forth [0–2] and fifth [0–3] mounds of the BIK and modern surface soil [0–4] (termed background soil) (Fig. 1).

The age of paleosols in the vertical chronosequence has been determined based on AMS dating. The degree of a paleosol profile development helped to estimate the duration of the each soil formation. The time of burials of paleosols in the horizontal chronosequence has been determined using the stratigraphic correlation with the soils of the vertical chronosequence.

The ^{14}C dating has been made using AMS measurements at the Center of Isotope Research of Groningen, the Netherlands. The main techniques we used to reconstruct landscape and climatic changes consisted of comparative profile and genetic studies of background soils and paleosols buried in different time (Alexandrovskiy, 1988).

Results

Soils of the vertical chronosequence developed during the interruptions between consecutive stages of the BIK construction were considerably different in their profiles development. Their age or the duration of their formation can be estimated based on the degree of profile development in the following way.

The paleosol 1 on the first mound at the central part of the BIK was divided into two well developed soils: 1–1 and 1–2. The total time span of the first mound and the paleosols 1–1 and 1–2 formation was 500–800 years. The paleosol 2 on the second mound of the BIK was the least developed, the duration of its formation was 20–30 years. The paleosol 3 and 4 was weak developed. The duration of the paleosol 3 and 4 formation was about 100 years for each. From the AMS dating the age of the paleosol 4 has been best determined (Table 1). The results of calibration of this date and the duration of the paleosol 4 development enable to refer the time of its formation to the chronointerval 2550–2450 cal. BC.

No.	Sample	Lab. code	^{14}C age, years BP	Calibrated age, years BC
Ip-6	Charcoal, paleosol 4	GrA-12126	4000 ± 40	2567–2519, 2499–2469
Ip-8	Fired grass, paleosol 3	GrA-13652	4080 ± 40	2839–2815, 2669–2643, 2641–2569, 2519–2499
ipt9	Fired grass from the paleosol 3	GrA-12406	4120 ± 70	2863–2809, 2779–2773, 2759–2719, 2705–2617, 2611–2579
ipt10	Charcoal from the third mound , paleosol 3	GrA-12414	4100 ± 70	2861–2811, 2755–2723, 2701–2573, 2515–2501
ipt2	Fired grass, paleosol 1	12403	4150 ± 80	2875–2603
ipt1	Fired grass, paleosol 1	12402	4470 ± 70	3335–3029
ipt4	Charcoal, paleosol 1	12440	4700 ± 70	3627–3373
ipt13	Charcoal, hole 1, mound 1	12412	4640 ± 90	3627–3139

Tab. 1. Results of radiocarbon dating.

For paleosol 3 calibrated interval of its age is wide due to considerable oscillation of the calibrated curve in that time. However, considering that the paleosol 3 had developed for about 100 years just before the paleosol 4, its formation can be referred to the interval 2650–2550 BC. In that case the paleosol 2 had developed for the interval 2700–2650 BC. The paleosol 1 on the first mound had developed for a long period and were dated as 4150 ± 80–4700 ± 70 years BP. Its formation can be referred to the interval 3500–2700 cal. BC.

The ages of paleosols of the horizontal chronosequence was determined as follows. These paleosols can be classified as Solonetzs. All of them began to develop simultaneously at the beginning of the Holocene. Under the central part of the BIK the paleosol 0–1 was buried about 3500 BC, under the end of the forth mound (paleosol 0–2) - about 2550 BC and under the fifth mound (paleosol 0–3) - about 2400 BC.

Paleosols of the horizontal chronosequence were buried in different time: paleosol 0–1 - 3500 BC, 0–2 - 2550 BC, 0–3 - 2400 BC.

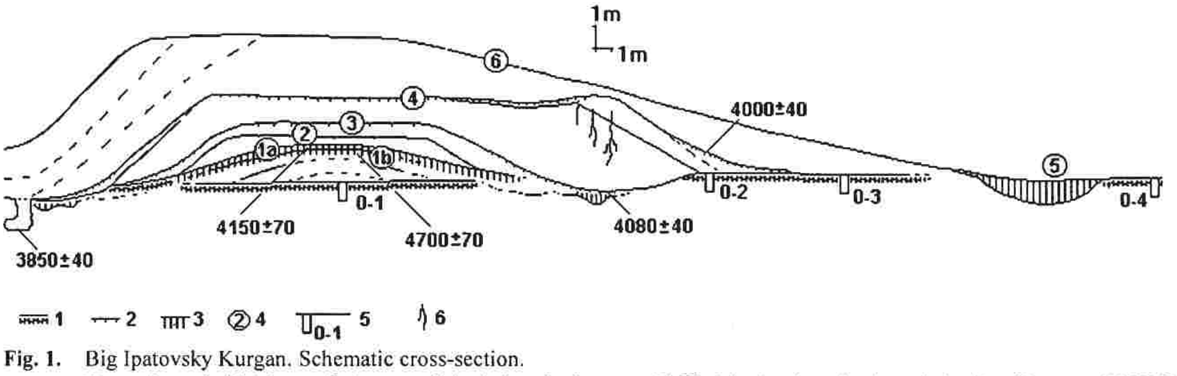

Fig. 1. Big Ipatovsky Kurgan. Schematic cross-section.
Key to legend: (1) Mature Solonetz soil buried under kurgan; (2) Weakly developed paleosols inside of kurgan; (3) Well developed paleosols inside of kurgan and in the ditches; (4) Vertical chronocequence of paleosols: [1a] and [1b] paleosols on the first mound, [2] weakly developed paleosol on the second mound, [3] paleosol 3 with carbonate on its surface, [4] paleosol 4 with the dissication cracks, [5] ditch, [6] modern soil; (5) Horizontal chronosequence of soils: [0–1]paleosol buried under the first mound, [0–2] paleosol buried under the forth mound, [0–3] paleosol buried under the fifth mound, [0–4] bachground soil; (6) Dessication cracks under the paleosol 4.

Discussion and conclusion

Paleosols of horizontal chronosequence buried under the different age mounds of the BIK were similar in the most features between each other and with background Solonetzic Chestnut soils. Only the depth of gypsum in their profiles was different because it responses quickly to changes of climate moistening. In the paleosol 0–1 buried at 3500 BC the depth of gypsum was 130–160cm, in the paleosol 0–2 buried at 2550 BC - 90–110 cm, in the paleosol 0–3 buried at 2400 BC - 110–125 cm and in the background soil - 160–210 cm. The driest climatic conditions of pedogenesis were likely to be at 2550 BC. At 2400 BC the climate became more humid.

The features of paleosols in vertical chronosequence are indicative of similar climate changes. The features of the arid stage of pedogenesis were absent in the paleosols 1 and 2, and they occurred in the paleosols 3 and 4.

The paleosol 3 went through two stages of pedogenesis at least. The features of the first stage preserved in ditches where the thick humic horizons developed as a result of additional inflow of water of atmospheric precipitation from the kurgan surface. Then in the second stage of pedogenesis in the upper part of these humic horizons the light coloured carbonate horizons developed. Similar carbonate horizons testified to the considerable dry climatic conditions developed on the surface of the BIK about 2550 BC. On the surface of the paleosol 3 the remains of fired grass were abundant. They may be indicatives of fires (conflagrations). At the same time the first desiccation cracks occurred.

The paleosol 4 went through two stages of pedogenesis also. The desiccation cracks up to the 3 m deep and mainly allocated in the south part of the BIK were referred to the first dry stage of pedogenesis (Fig. 1). In passing from dry environment to more humid the slope processes became more active, and thick colluvial deposits occurred in the bottom of the BIK southern slope. The well-developed humic horizons on the flat surface of the fourth mound of the BIK and the subsident depression as a result of water stagnation on the clay layer covered its flat surface may be attributed to the humid environment.

A very dry climatic period in the Third Millenium BC were found by palinologists in the Don River basin and characterized as a climatic catastrophe (Spiridonova, 1991). Based on conventional 14C dating this period was 3800–3900 years BP or 2200–2400 cal BC.

Similar arid climatic event was determined in the Mesopotamia region (Weiss et. al., 1993) but ^{14}C age of its and in the Don River basin as well were some younger than that in Ipatovo.

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The Holocene Sedimentation in Sandstone Rockshelters of Northern Bohemia

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ABSTRACT. Thirty new Mesolithic sites (7–10 millennium BC) were found under sandstone rockshelters of the Northern Bohemia together with abundant fossils. The first half of the Holocene is significantly different from the last few thousand years - the substrate was calcareous, mixed forest prevailed, some 40 species of molluscs lived near searched sites. The gradual environmental change was puctuated by a most intense environmental degradation of the whole Holocene during Late Bronze to Early Iron Age. This environmental crisis can be characterised by erosion (deforestration?), de-calcification of the soils and sediments that resulted in pine forest spreading and consequent profound change of fauna and flora (e.g. only 5–7 species of snails had survived in the searched area).

KEY WORDS: Holocene, Mesolithic, sedimentation, rockshelters.

Introduction

The Upper Cretaceous (Cenomanian-Turonian) sandstones are forming in Northern and Eastern Bohemia large areas that can be characterised by a special landforms called the castellated rocks. A maze of narrow, steep forested canyons and dry gorges some 20–60 m deep, plateaus covered by agricultural, often loessic soils, artificial ponds and numerous villages are composing a specific cultural landscape protected as several landscape protected areas (Kokořínsko, Broumovsko, Český ráj, Labské pískovce) and the České Švýcarsko National Park.

Our multidisciplinary team composed of experts on archaeology, paleobotany, geology, mineralogy, molluscan and vertebrate paleontology discovered during last ten years together with