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Deposits of the rock shelter Svetly (the Middle Urals): Comparison of paleosol and paleotheriological data and paleoenvironmental reconstructions based on them

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ABSTRACT

Paleosols, surface soils, mammal bone remains of Late Pleistocene and Holocene deposits of the rock shelter Svetly were studied. The joint analysis of paleontological and paleosol data was carried out. The paleoenvironment underwent considerable transformation, which resulted in changes in type of soil formation and in the structure of the mammal community. Cryoarid conditions with mammoth complex mammals of Late Pleistocene layer changed to warmer and more humid conditions with spread of open landscapes, along with forest biotope formation. The most favorable conditions in terms of heat and moisture supplies continued during the Middle Holocene, resulting in formation of dark humus horizons. By the late stage of this epoch, taiga fauna had formed. Later conditions become cooler. Chronological heterogeneity of bone remains in the upper layer is caused by a complex genesis of local sediments. Staged process of sedimentation resulted in polygenetic soil profiles. Common structure of deposits is indicative of the general trend in the paleoenvironmental evolution. The study of separate layers within the soil profiles largely reveals the concurrent nature of soil and fauna evolutions.

1. Introduction

Paleogeographical reconstructions deploy a variety of methods and indicators, each capable of identifying paleoclimatic characteristics. Fossil organisms seem to display high temporal and low spatial resolutions. Soils can retain information about prolonged periods of environment evolution, hence paleosols possess low temporal resolution, but at the same time high spatial resolution (Targulian and Sedov, 2004). Paleontological and paleosol indicators may greatly complement each other, and their conjugate analysis leads to more detailed reconstruction of the past environment (Dobrovolskiy and Makeev, 2009).

Paleontological research of the Urals has been carried out since the late 19th century. This period has seen massive growth in paleoteriological findings of large and small Pleistocene and Holocene mammals (Smirnov, 2003).

Paleopedogenesis in the Middle Urals has not been given sufficient attention. As far as we know, there is only one special article on reconstruction of conditions underlying the formation of buried soils in this area (Nekrasova and Uchaev, 2012). At present, local peculiarities of soil evolution are not known. Historical development of the Middle Ural soils has not been correlated with that of the adjacent areas.

The purpose of this article is parallel study and conjugate analysis of the species composition and population structure of mammals, pedogenic features of surface and buried soils of Late Pleistocene–Holocene deposits in the rock shelter Svetly (the Middle Urals) and paleoenvironmental reconstruction based on them.

2. Regional setting and objects

Rock shelter Svetly is located on the right bank of the river Serga in the National Park «Olenyi Ruch'i», the Middle Urals, Russia (56°32′N, 59°16′E). By physiogeographical division, the territory is included in the southern taiga macroregion of Ufa–Chusovaya district (depression), representing the West Ural zone of orogenesis of the Middle Ural mountains (Prokaev, 1976). The valley of the Serga river is deep and narrow, dissect the Upper Silurian and Lower Devonian limestone formations. On most sites, there are no terraces above floodplains, the banks are predominantly steep and consist of primary rocks. Karst is fairly common.

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The climate is continental, with the average annual precipitation of 500 mm. The average monthly temperatures of air are −17.0 °C in January, and 16.6 °C in July, the mid-annual temperature is 0.3 °C ("Climate…", 1965). In the Serga river valley, pine forests prevail and some areas abound with larch trees. The agroclimatic indicators of the given area characterize it as insufficient in heat and excessive in moisture supply. The soil cover structure of the area is dominated by mosaic combinations of soddy-calcareous soils, gray forest residually calcareous soils and gray forest soils (Gafurov, 2008) (close to Rendzic Leptosols, Endocalcaric Retisols and Haplic Retisols, respectively).

The rock shelter Svetly is situated in the base of a 7 m high limestone rock. The height from flood-lands is about 3 m and from the Serga River about 6 m. The site has a south-eastern exposition. The width of the rock shelter is 5.7 m, the length 1.6–2.0 m. A small buried grotto can be seen in the base of the rock. In the northern part of the rock shelter, sediments were excavated. The total area of the excavation square is 6 m^2 and the maximum depth of the pit is about 2.15 m (Fig. 1).

3. Materials and methods

Excavations of the rock shelter Svetly have been held by the scientists of Institute of Plant and Animal Ecology UrB RAS (IPAE UrB RAS, Yekaterinburg) in 2005–2007. They have resulted in many osteological and archeological findings (Volkov et al., 2007).

The excavation and sampling of fauna and radiocarbon investigations followed standard methodology (Gromov, 1955; Arslanov, 1987). Deposits have been taken in separate 10 cm levels and washed in sieves with a mesh size of 0.8 mm to recover small vertebrate remains (Gromov, 1948; Agajanian, 1979; Guslitcer, 1979). Species of mammal remains have been identified using the etalon collections of IPAE UrB RAS and literature (Gromov and Polyakov, 1977; Gromov and Erbaeva, 1995; Borodin, 2009). Species ratios in fossil faunas have been calculated on the basis of the minimum number of individuals (MNI). The paleontological collections are kept at the IPAE UrB RAS.

Radiocarbon dating was conducted at the Isotope Center of The Herzen State Pedagogical University (SPb, St. Petersburg) and in the A.N. Severtsov Institute of Ecology and Evolution (IEMEG) of the RAS (Moscow).

To analyze bone remains for their chronological similarity, organic matter amounts reserved in fossil bones have been estimated by Differential Thermal Analysis (DTA) according to Smirnov et al. (2009). Only vole lower jaws have been used as bone specimens because they are the most numerous and suitable for species identification. Organic matter amount data have been obtained on the high-precision derivatograph "Netzsch STA 449F3 Jupiter" (only for specimens from layers 3–5). For layer 2, the data from Smirnov et al. (2009) have been used.

Buried and surface soils of the excavation site and surface soils of the adjacent sites (on the top and the slope of the rock above the rock shelter) were examined. pH of aqueous soil extract were measured by potentiometry, mobile phosphates in Machigin extract by colorimetric method by Denige; water-soluble sulphates by thermogravimetric analysis; total organic carbon (TOC) by potassium dichromate oxidation by Turin (Arinushkina, 1970), fraction-group humus composition by Ponomareva and Plotnikova (1975). Optical density of humic acid was measured in the extract after soil decalcification with the spectrophotometer PE-5400 (Ekros). Soil particle-size distribution was determined by laser diffraction with Analysette 22 Nanotec (Fritsch) after the soils had been treated by 4% sodium pyrophosphate.

4. Results

4.1. Stratigraphy

The sedimentary sequence contains 5 layers (Fig. 2).

Layer 1. Modern humus layer, slightly sodded, consisting of dry undecomposed plant remains, friable and penetrated by abundant roots. The layer contains few bones of birds and mammals. Layer 2. Light-gray or whitish, loose unstructured loamy soil. Stone content increases from 10% in the upper part of the layer up to 80% in the lower part. The layer contains numerous vertebrate bone remains.

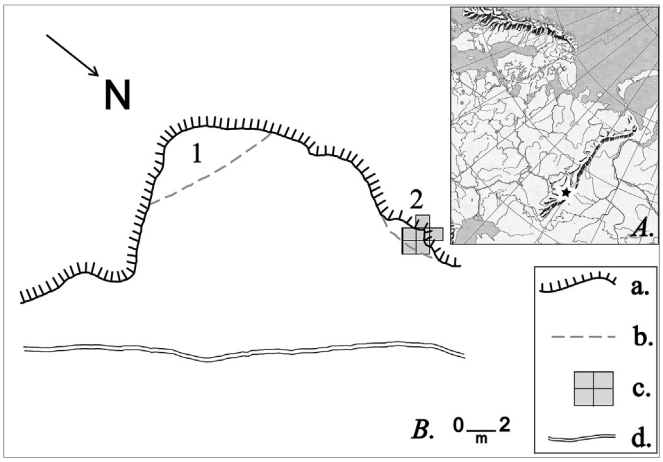

Fig. 1. The rock shelter Svetly: A. General map. B. The scheme of Svetly rock. 1. Svetly grotto. 2. Rock shelter Svetly. a. Limestone rock. b. Drop line. c. Excavation (thick line – cross-section). d. Path.

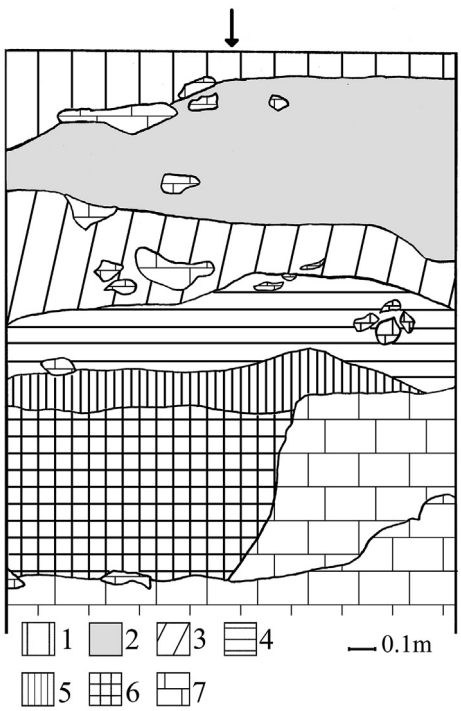

Fig. 2. The rock shelter Svetly: stratigraphy of the south wall of excavation. 1. Layers 1. 2. Layer 2. 3. Layer 3. 4. Layer 4. 5. Layer 4a. 6. Layer 5. 7. Limestone stones and boulders.

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