Catena xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

# Morphology and micromorphology of the loess-paleosol sequences in the south of the East-European plain (MIS 1–MIS 17)

P.G. Panin*, S.N. Timireva, T.D. Morozova, Yu.M. Kononov, A.A. Velichko

*Institute of Geography, Russian Academy of Sciences, Staromonetny 29, 119017 Moscow, Russia*

ARTICLE INFO

*Keywords:*
Paleosols
Loess
Pleistocene
Interstadial
Interglacial

ABSTRACT

The micro- and macromorphological studies performed on the loess-soil sequences in the south of the East-European Plain permitted to identify and describe the type of soil-formation processes that took part in the development of interstadial and interglacial paleosols. Four paleosol complexes are distinctly identified within the limits of the studied region: Vorona (MIS 13/15), Inzhavino (MIS 8/9 or MIS 10/11), Kamenka (MIS 6/7 or MIS 8/9), Mezin (MIS 5); besides, there are the Bryansk interstadial paleosol (MIS 3) and Rzhaksa interglacial paleosol (MIS 17), both well identifiable in the region. The results obtained are in general agreement with the earlier conclusions by Velichko et al. (2012) about a general reduction of heat and moisture supply and an increase in aridity from the earlier towards later stages of the Pleistocene. The new data revealed, however, a few differences from the earlier concept. To mention but one example, we have found that the Kamenka interglacial (MIS 7 or MIS 9) paleosols formed in environments more humid than those of the Likhvin interglacial (MIS 9 or MIS 11).

## 1. Introduction

Loess occupies vast areas in the East European Plain, where loess-paleosol sequences (LPS) contain paleosol complexes (PC) datable to the Late, Middle, and Early Pleistocene. The loess-paleosol sequences demonstrate alternating series of loess and fossil soils that indicate changing environments and enable us to reconstruct climatic fluctuations from the beginning of the Pleistocene to the present days.

The paleosol complexes are represented in the region by interglacial and interstadial paleosols distinguished by differences in their profiles (Velichko et al., 2007; Velichko and Morozova, 2015). In the paper we apply the term 'profile' to a sequence of soil horizons typical for a certain type of soil. Soils dated to warm interglacials are noted for a fully developed profile with a set of genetic horizons (Little et al., 2002; Panin, 2007; Velichko et al., 2017a; and others). During interstadials, under conditions of insufficient heat and moisture supply, humus-accumulative soils formed, with horizons A and AB only. After the paleosol complex had been buried under loess material during the subsequent glacial time, the soil-forming processes stopped and initial soil characteristics were partially lost and replaced by others related to diagenesis processes. When studying LPS characteristics traditional techniques are mostly used, including: description of the sequence morphology; studies of the quartz sand grain morphoscopy; an assortment of physic-chemical analyses, such as grain size, bulk composition, mineralogical composition; determination of carbonate contents, humus, iron sesquioxides, pH, etc. (Velichko and Timireva, 1995; Nettleton et al., 2000; Muhs, 2007; Chizhikova et al., 2007; a.o.).

The wide experience in paleosol research gained by the present time has shown the studies of soil micromorphology in thin sections to be the most promising approach to the paleosol genetic identification. That approach makes it possible to recognize specific characteristics of the principal soil-forming processes in paleosols (Matviishina, 1982; Bronger and Heinkele, 1989; Bronger et al., 1998; Nettleton et al., 2000; Kühn et al., 2006; Stoops et al., 2010; Mason and Jacobs, 2013; Sprafke et al., 2014). The properties of the processes vary in their resistance to the time and diagenesis factors. The most resistant are the soil fabric, peds, voids, b-fabric, carbonate and gypsum pedofeatures, and some others. Here we consider in details the LPS structure at macro- and micro-levels, which forms the basis for correlating the paleosol levels and reconstructing specific features of the soil-forming processes, their intensity and stages in their development (Velichko et al., 2017c). The comparison between the results obtained on paleosols and characteristics of the modern soils makes possible the tracing of the changes in climate and environments within the Azov region.

## 2. Materials and methods

The works were performed in cooperation with specialists from the

* Corresponding author.
*E-mail address:* pgpanin@igras.ru (P.G. Panin).

https://doi.org/10.1016/j.catena.2018.01.032
Received 2 September 2017; Received in revised form 20 January 2018; Accepted 26 January 2018


Please cite this article as: Panin, P.G., Catena (2018), https://doi.org/10.1016/j.catena.2018.01.032

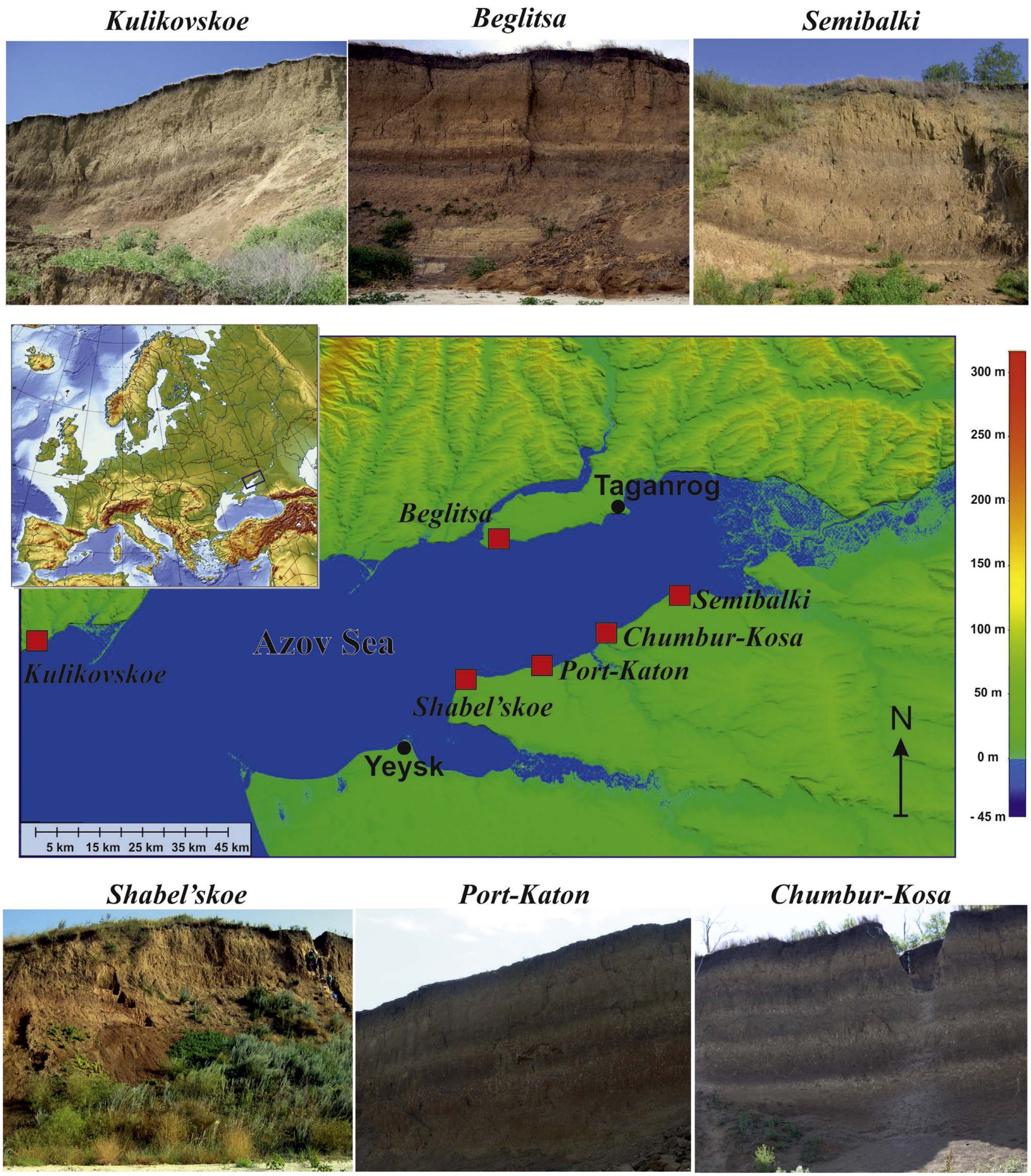


**Fig. 1.** The region under study with photographs of the main LPS sections (the topographic base taken from Shuttle Radar Topography Mission materials).

Southern Scientific Center (city of Rostov-on-Don) and the Geological Institute (Moscow) of the Russian Academy of Sciences. Since 2003 several main sections had been studied: Shabelskoye (N 46°51′34″; E 038°27′46″), Port-Katon-1 (N 46°52′39″; E 038°43′59″), Chumbur-Kosa (N 46°57′48″; E 038°56′47″), Semibalki-1 (N 47°00′35″; E 039°02′22″), Semibalki-2 (N 46°59′48″; E 039°00′53″), Beglitsa (N 47°07′38″; E 038°30′56″), and Kulikovskoye (N 46°52′58″; E 037°03′16,57″) (Fig. 1).

The loess-paleosol sequences are exposed in the coastal cliffs of the Azov Sea. The modern soils are Chernozems ordinary according to the Russian classification (Egorov et al., 1977; Shoba, 2011), or Chernozems Pachic according to the international classification WRB 2014 (2015); they are mostly ploughed at present. The climate is temperate continental. The temperature fluctuation range in a year amounts to ~28 °C on average, the maximum annual range is up to 70 °C. The