Quaternary International xxx (2016) 1–13

Contents lists available at ScienceDirect

Quaternary International

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

Middle to Late Pleistocene topography evolution of the North-Eastern Azov region

E.A. Konstantinov*, A.A. Velichko, R.N. Kurbanov, A.L. Zakharov

Institute of Geography, Russian Academy of Sciences, 119017, Staromonetniy pereulok 29, Moscow, Russia

ARTICLE INFO

Article history:
Available online xxx

Keywords:
Palaeotopography
Loess
Paleosol
Ancient erosion patterns

ABSTRACT

The structure of loess-soil sequences of the North-Eastern Azov region was studied in coastal outcrops and boreholes within four key areas of the terraces of different age. Based on the positions of paleosols in geological sections of interfluve areas, the palaeotopography during interglacial epochs of the last 500 ka was reconstructed. The analysis of the topography evolution showed that the most significant features of the primary fluvial-marine relief remained in subaerial stage of the surface development and were inherited even in modern relief. At the same time, in subaerial stage the surface of interfluves experienced considerable reworking due to loess accumulation, on the one hand, and erosion, on the other hand. It has been established that these processes were controlled by the glacial-interglacial climatic cycles; however, their intensity varied from cycle to cycle. Generally, before the Valdai (Weichselian) glacial epoch, loess accumulation prevailed on the interfluve areas. The intensity of erosion at that time was relatively low. During the Valdai epoch (by indirect evidence, during its final stage, MIS 2, ~29–12 ka), a phase of exceptionally intensive erosion was detected. Due to it, linear erosion and slope processes developed even within fairly gently slope (2–4°) areas. It has been determined that during this time, the upper parts of gullies were growing rapidly towards watersheds. In the modern topography, a branched pattern of relic hollows inherits their position.

1. Introduction

Sections of the loess-paleosol sequences (LPS) are of considerable interest for the investigations of the morphodynamics of interfluvial areas of the southern East European Plain during the Pleistocene. Reconstructing the ancient topography of the loess areas becomes possible due to the presence of buried paleosols, the horizons of which mark the position of the ground surface during interglacial and large interstadial periods of the Pleistocene (Velichko et al., 2009a, 2012). Documentation of the relative positions of paleosols of different age, together with the texture analysis of deposits (determining erosional contacts, traces of slope processes, etc.) allows to reconstruct the topography evolution and to link it to the history of climatic fluctuations during the Quaternary (Marković et al., 2006, 2008; Vandenberghe et al., 2014). Such reconstructions show the response of erosion and accumulation within the interfluves and adjacent upper branches of the erosional pattern to climatic changes. This, in its turn, may serve as a theoretical basis for forecasting the evolution of topography under conditions of climate change.

The North-Eastern (NE) Azov region is one of the most promising areas for such investigations. Due to prevailing loess accumulation during the Pleistocene and active wave erosion of the coasts of the Azov Sea during the Holocene, the structure of the LPS can be observed within dozens of kilometers in natural coastal outcrops. This, in its turn, allows the reconstruction of the topography development during the last ~500 kyr. It is worth mentioning that, surprisingly, during more than centennial history of investigations of loesses in the Azov region, there were no special works devored to palaeogeomorphological reconstructions. Most of the researchers report only rough sketches showing the position of paleosols and other stratigraphic units in the coastal outcrops (Khokhlovkina, 1940; Veklich, 1968; Matsui et al., 1981). In some cases, more thorough investigations of the coastal outcrops were performed as well (Lebedeva, 1972; Markov, 1976). However, all the mentioned works lack important details, as no elevation measurements of specific horizons was done.

Such lack of data can be explained to some extent by the fact that, until the recent time, the chronostratigraphical scheme of the

* Corresponding author.
E-mail address: eakonstantinov@yandex.ru (E.A. Konstantinov).

http://dx.doi.org/10.1016/j.quaint.2016.04.014

LPS of the northern Azov region was partly incomplete. Works conducted during the last ten years (Dodonov et al., 2006; Tesakov et al., 2007; Velichko et al., 2009a, 2009b) helped considerably in filling this gap. Velichko et al. (2012) suggested a correlation between loess stratigraphic units of the Don-Azov region and general stratigraphic scheme of East European Plain (Little et al., 2002; Velichko et al., 2006, 2010b). The correlation is based on data integration, namely on detecting the relations between the LPS, the underlying lagoon-alluvial deposits of a known age, faunal remains from loess and soils, palaeomagnetic data, and the results of radiocarbon dating. According to this scheme, the main phases of paleosols' and pedocomplexes' (PC, where soil profiles of different ages are superimposed) formation are associated with the following Pleistocene warm epochs and marine isotope stages (the age limits of MISs – after Lisiecki and Raymo, 2005): Briansk paleosol (L1SS1)[1] – Briansk Interstadial, MIS 3, ~29–57 ka; Mezin PC (S1) – Mikulino Interglacial–Early Valdai interstadial, MIS 5c-5e, ~96–130 ka; Kamenka PC (S2) – Kamenka Interglacial, MIS 7, ~191–243 ka; Inzhavino PC (S3) – Likhvin Interglacial, MIS 9, ~300–337 ka; Vorona PC (S4+S5SS1) – Ikorets Interglacial–Muchkap Interglacial, MIS 11–13, ~374–533 ka. In this way, a background for the investigations of the topography evolution of interfluve areas in the NE Azov region during the Pleistocene was established.

2. Material and methods

The reconstruction of the palaeorelief in the present study is based on the analysis of the position of geologic boundaries of different horizons distinguished in the LPS. The main boundaries showing ancient ground surfaces (or buried topography) in the studied sections are paleosols. They reflect phases when the surface remained stable; the duration of such phases can be assessed by the development of the soil profile (Sokolov and Targul'yan, 1976). The most relevant for further investigations are paleosols of stratigraphic importance, which can be considered as geochronologic benchmarks, well distinguished by a variety of so-called morphotypical features (soil structure, color, profile type, etc.), even in sections situated far from each other. In the northern Azov region only automorphic paleosols and PCs in the watershed areas have stratigraphic importance. They formed during interglacial and long interstadial periods in the conditions of surface stability (during several thousands of years, or more) and relatively high temperature and moisture. Morphotypical features for paleosols and PCs of different age were elaborated by Morozova (1972, 1995) and Velichko et al. (1973, 2012). Morozova also conducted diagnostics of the paleosols (i.e. their attribution to a certain soil type). Based on these studies, we were able to identify paleosols of different age in coastal outcrops and in cores during fieldwork.

Another type of geologic boundaries documented in the sections of the LPS of the Azov region is represented by erosional contacts which are accompanied by stratigraphic unconformities. Erosional contacts in the studied sections sometimes are marked by embryonic soils, but mostly lacking any traces of soil formation. Such borders can be regarded as ancient erosion surfaces, which were relatively quickly buried afterwards. These surfaces, especially if they are wide-spread, can be considered as the traces of erosion phases caused by climate fluctuations, when erosion prevailed over accumulation within interfluve areas.

Four key coastal areas of the Gulf of Taganrog were selected for the field investigation: Beglitsa, Semibalki, Shabelskoe, Melekino (Fig. 1). The key areas belong to lagoonal-alluvial terrace levels of different age; the thickness and structural complexity of the loess cover varies considerably between them. Within each area, key sections were thoroughly studied in outcrops using a set of analytical methods. Based on the stratigraphy of the key sections, geological horizons were correlated in two directions: along the coastal cliff and perpendicular to the coast using manual drilling. The elevation of the horizons in outcrops was measured using a bubble level and measuring tape; their positions were marked using a GPS. During the drilling of borehole profiles, a hand drill was used; it was equipped with a set of rods and samplers allowing to drill boreholes up to 15 m deep and to obtain a practically undamaged cores with the diameter of 3 or 7 cm. The borehole profiles were set across the main elements of topography: from the high interfluve surface to the thalwegs of erosional forms. This allowed tracing the relations between the modern and ancient topography most accurately. Together with the measurements of elevation of certain geological horizons, a lithological description was made for each layer: the structure, color, texture, and newly formed inclusions were characterized. Along with this, morphologic description of the paleosols with details on each soil horizon was done.

3. Results

3.1. Beglitsa key area

Beglitsa key area (Fig. 2) is located on the northern coast of the Gulf of Taganrog on the so-called Beglitsa (II) terrace formed in the Middle Pleistocene, according to Lebedeva (1972). It occupies the south-western part of the peninsula washed by the Gulf of Taganrog from the south and by the Mius Lagoon from the north. The Beglitsa terrace has a subhorizontal surface with heights of 15–17 m a.s.l. The surface lowers westwards, in the direction of the Mius Lagoon, to 12–14 m a.s.l. In the north, the Beglitsa terrace is limited by a shallow ledge of the terrace (V, Platovian, according to Lebedeva, 1972) formed during the early part of the Middle Pleistocene, the heights of which vary from 35 to 40 m a.s.l. A large hollow open from both sides stretches along the inner margin of the Beglitsa terrace. It is 4–7 m deep and 700–900 m wide. Its length is about 10 km. The shape of the hollow (curved with a constant width) indicates that it might be an ancient river bed.

The structure of sediments outcropping in the coastal cliff of the Beglitsa terrace is described in details in the section Beglitsa-2010 (Velichko et al., 2012). At the bottom (from 0 to ~4 m a.s.l.), a layer of clays, sands and loams of subaquatic genesis with parallel horizontal lamination lies. Within this layer, remnants of the Khazarian faunal assemblage mammals (upper part of Middle Pleistocene) were found: *Mammuthus trogontherii Pohl.* (Ivanova and Praslov, 1963), *Mammuthus cf. chosaricus*, *Megaloceros* sp., *Lagurus lagurus* (Tesakov et al., 2010). The subaquatic deposits are overlain with unconformity by a layer of light loess-like loam of subaerial genesis, which continues up to the surface. Its color varies from yellowish grey and pale yellow to brown and dark grey. This loamy layer contains at least four levels of buried soils. At the depths of 4–5.5 m a.s.l. PC of light-brownish color lies. The type of the soil and its stratigraphic position indicate that this is the Kamenka PC (S2). At the depths of 7–9 m a.s.l. a double buried PC lies, determined by Velichko et al. (2012, 2013) as the Mezin pedocomplex (S1). The lower Salyn phase (S1SS3) of the Mezin PC,

[1] In the text the international loess/soil (L/S) units are in the brackets after local stratigraphic units. The L/S nomenclature is based on Chinese loess scheme (Kukla, 1987; Kukla and An, 1989; An et al., 1991) and new pan-European loess stratigraphic model (Panaiotu et al., 2001; Bogutsky and Łanzont, 2002; Marković et al., 2006, 2008, 2009, 2011, 2015; Jordanova et al., 2007; Buggle et al., 2009; Bokhorst et al., 2011; Jary, 2011; Timar-Gabor et al., 2011; Jary and Ciszek, 2013; Újvári et al., 2014).