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Glacial–Interglacial cycles in arid regions of northern Eurasia

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Abstract

Considering evolution of arid environments in northern Eurasia through the ''glaciation–Interglacial'' cycle the author adheres to the opinion as stated by I.P. Gerasimov. According to the latter, Pluvial stages in arid regions correspond to glaciations in the arcto-boreal zone, while xerothermal stages are synchronous to Interglacials. There are new paleofloristic evidence obtained in support of this opinion. In particular, it has been inferred from pollen spectra that during Pluvial stages boreal flora (including forest species) penetrated into the Caspian Lowland, Turanian Plain and to the Black Sea coast—i.e., the regions of dry steppes and deserts at present. At the xerothermal stages the typical steppe and desert landscapes of arid zone were restored.

1. Introduction

Characteristic features of the Central Asia environmental evolution through Glacial–Interglacial cycles have been first summarized by Gerasimov and Markov (1939). This opinion, based on the geomorphology of the Turana Plain and some botanical data may be stated briefly as follows. The Central Asia plains are remote from continental ice sheets, and Glacial–Interglacial cycles were manifested there as alternating Pluvial and xerothermal epochs. The alluvial plain formation was associated with ''phases of increased river discharge in Central Asia, the latter seems naturally to be attributed to phases of active glacier melting in the Pamir–Alai and Tien Shan mountain systems and to Pluvial climatic epochs'' (Gerasimov and Markov, 1939, p. 402). Gerasimov named the Interpluvial xerothermal intervals ''deflation phases'' as the soil in deserts is mostly loose and insufficiently fixed by scanty vegetation. ''Warming in northern regions was marked by expansion of thermophilic and hydrophilic trees. In the South, under conditions of moisture deficiency, the Postglacial warming could result in further drying; therefore, it is not inconceivable to suggest that the *Atlantic*, (that is relatively wet and warm) period in the North corresponds to the Postglacial *xerothermal* (dry and warm) period in the South'' (Gerasimov and Markov, 1939; italicized by the author). Proceeding from this statement, a number of leading Russian geographers agreed in that loess in the Central Asia formed during xerothermal (''deflation'') epochs, and therefore should be considered ''warm facies,'' as distinct from the European ''cold'' loess (Gerasimov and Markov, 1939; Berg, 1947; Gerasimov, 1962).

In the recent decades an alternative concept has been developed. It states that, all over Eurasia, from the formerly glaciated and Periglacial zone of Europe through arid regions in Central Asia to southeastern China, ''epochs of loess formation were related to coolings/glaciations, while soils developed on loessial substrate during warming/Interglacials. This regularity is traced both in desert loess regions and in temperate zone of Periglacial loess'' (Dodonov, 2002, p. 124). In other words, there was not any paleoenvironmental differentiation in the processes—cooling and drying of climate (accompanied by loess accumulation) proceeded simultaneously all over the continent; similarly, warmer and wetter phases featured soil formation on the loess substrate everywhere, from the central East European Plain to China.

2. Overview of paleobotanical data

Following are brief discussions of some paleobotanical evidence available from dry steppes and deserts, from the Crimea to the Pamir–Alai foothills, which may give some insight into environments of cold and warm intervals. A.A. Nikonov studied a section on the Azov coast of the Kerch Peninsula (Cape Kazantip) where a well developed deeply

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humified *paleosol* developed on shell sand was overlain by sandy loam with shell fragments (Nikonov and Pakhomov, 1993). The soil was dated by ^{14}C to $34\,270 \pm 1410$ yr BP, and therefore can be related to a stage of the Valdai glaciation. As follows from pollen analysis, the lower part of the soil developed in environments of grass and herb steppe (southern type). Somewhere in the middle of the soil accumulation (stratigraphically above the date) the vegetation began to acquire more of a forest character. Pine pollen amounts to 50–70%. The soil was likely developed in relatively temperate forest–steppe environment, with pine stands growing on flat interfluves, at annual precipitation of 400–500 mm (that is 100–150 mm above the present-day level).

Another series of Late Pleistocene paleosols dated within an interval of 19–1.5 kyr BP has been studied on the northern coast of the Kerch Peninsula, near the town of Shchyolkino and in the upper part of the western slope of Aktash Ridge (Nikonov et al., 1993). Subrecent pollen spectra (indicative of the present-day vegetation) were used as a reference assemblage when interpreting fossil spectra. The recent spectra are dominated by Chenopodiaceae pollen, with a considerably lower proportion of dicotyledonous herbs (Fig. 1). Allowing for low pollen productivity of Gramineae, it may be safely assumed that 6% content of their pollen in the assemblages indicates a significant participation of grass in plant communities. No natural tree communities are found in the region at present, and occasional pollen grains of pine are presumably brought by wind from the nearest planted stands on the southwestern coast of Kazantip Bay. On the whole, the subrecent samples represent adequately the modern steppe and desert–steppe landscapes of the Kerch Peninsula. Therefore, former environments may be reconstructed from fossil spectra with equal confidence.

Pollen assemblages recovered from a paleosol dated to about 19 kyr BP differ drastically from the subrecent ones. They are dominated by tree pollen (AP up to 70%), mostly that of pine (64%), with admixture of birch (4%) and occasional grains of spruce. There are occasional spores of Polypodiaceae. Herb and grass pollen amounts to 8% only, and species composition is rather poor. The assemblage suggests pine forests with birch and ferns in the undergrowth were common on the Kerch Peninsula about 19 kyr BP. The evidence obtained strongly suggests a noticeable increase in rainfall in the Crimea at the Last Glacial Maximum (LGM), while Summer drought typical of today was essentially mitigated. The environments of the subsequent time interval may be inferred from pollen histograms obtained for a younger paleosol dated to about 13 kyr BP. *Pinus* pollen is still dominant (74%), though herb composition is more diversified.

The mid-Holocene assemblages (~7 kyr BP) reveal somewhat similar landscapes. But later pollen spectra characteristic of the Holocene soils dated to 5–1.5 kyr BP indicate quite different environments. Forest communities were drastically reduced in area. The amount of *Pinus*

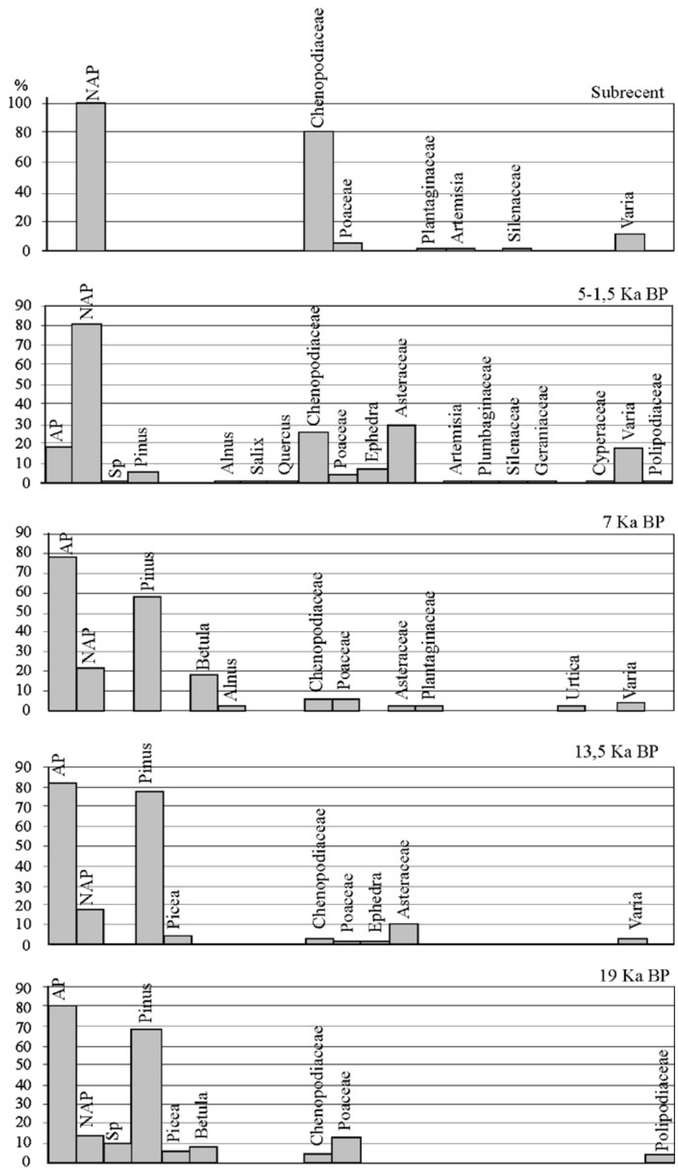

Fig. 1. Pollen histograms of fossil soils of various age and subrecent sample (the upper histogram) from the northern coast of the Kerch Peninsula (Crimea).

pollen (12%) suggests pine stands persisting in river valleys. On interfluves dominant were herbs and grass. NAP pollen proportion is as high as 85%, including Asteraceae, Gramineae and Chenopodiaceae, with a noticeable participation of Ephedra. The spectra indicate deterioration of conditions towards *aridity and warming*,

As for southeast of the European Russia, there are abundant data indicative of forest expansion into steppes during one of the stages of Khvalynian transgression (Grichuk, 1952, 1954, 1982). In a number of Late Pleistocene sections in the Lower Volga and northwestern Caspian regions there have been identified stratigraphic horizons with noticeable or dominant presence of taiga plants in pollen assemblages. Grichuk attributed them to the Valdai Glacial time and suggested that at the Last