

Reconstruction of vegetation and climate of the past of the central Caucasus for materials from the Tarskoe swamp

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ABSTRACT. The reconstruction of vegetation changes of foothill zone in the central part of the North Caucasus based on the data of the Tarskoe swamp is presented. The swamp is the largest in this region of the Caucasus and is the most promising peat paleoarchive. It has been studied earlier, but the cores were poorly dated. The Tarskoe was re-drilled, the sediments were dated, and pollen and microcharcoal analysis were carried out. Twelve radiocarbon dates were obtained for the deposits, the age of the bottom sediments was about 4.6 cal. ka BP. Based on the data obtained, it was possible to establish that the bogging occurred against the background of more open landscapes, with a greater proportion of meadows than at present. Only after 4.4 cal ka BP broad-leaved forests become more closed, in their composition *Fagus* were dominant, with alternating admixture of *Carpinus*, *Ulmus* and *Alnus*. The increase of *Alnus* after Cyperaceae is most likely reflect local changes, since this tree species settled in the swamp at a late stage of its development. The dynamics of fire activity is interesting, it is most pronounced in the intervals between 4.4-3.3 cal. ka BP and than from 2.2 cal. ka BP until present. The frequency of fires is probably related not to climate, but to anthropogenic activities. In almost all cases, this coincides with the appearance of cultivated cereals pollen and with an increase in the diversity and quantity of grasses associated with humans (weeds). Thus, the obtained data for the first time give a possibility to construct a dated sequence of changes in the composition of broad-leaved forests of the belt of Caucasus piedmont and confirmed the appearance of cultivated cereals pollen about 4.3 cal. ka BP, which is probably associated with agriculture of the Maikop culture.

Keywords: North Caucasus, Holocene, pollen analysis, paleoecology, microcharcoal

1. Introduction

In the North Caucasus, very few Holocene natural archives have been studied, and we can't reconstruct vegetation history or assess the long-term influence of agriculture and pastoralism on mountain ecosystems.

The Tarskoe swamp is one of the most promising sites. It had been studied twice before 2019. The first study did not provide dating for the core (Neishtadt, 1955; 1957); at the second, the core did not contain the upper sediments, they might have been removed during peat harvesting (Knyazev et al., 1992). The new drilling in 2019 fixed these problems.

The Tarskoe swamp is one of the largest peat bogs in the mid of North Caucasus, it occupies about 20 ha in the basin between the Lesisty and Pastbishchny ranges (42°57'46"N, 44°43'32"E; 806 m a.s.l.). The climate is temperate continental with warm and very humid summer and medium cold, snowy winter. The

swamp is located to the low-mountain belt of broad-leaved forests dominated by *Fagus orientalis* Lipsky and *Carpinus betulus* L. with *Quercus robur* L., and an admixture of *Corylus avellana* L., *Ulmus glabra* Huds. and *Pyrus caucasica* Fed. Swamp vegetation is formed by *Carex* sp. and *Phragmites australis* (Cav.) Trin. ex. Stend with *Matteuccia struthiopteris* L. and *Sphagnum* sp., with thickets of *Alnus glutinosa* L. in some places. The swamp was drained for pasture and haymaking in the mid-20th century. Traces of drains are still visible. The new drilling was made between them in an undisturbed area.

2. Materials and methods

2.1. Sediment description

A 327 cm core was collected using a Russian corer with a 5 cm diameter, the Tarskoe core consists of 7 sections, 50 cm long each. The lithology of the core:

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Received: July 01, 2022; Accepted: August 13, 2022;

Available online: September 02, 2022

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0 – 276 cm: moss-herbs peat (*Sphagnum*, Bryidae, *Carex*, *Eriophorum*) with interlayer of total sphagnum peat from 140 cm to 153 cm.

276 – 290 cm: herbaceous decomposed peat

290 – 300 cm: clay with herbaceous detritus

300 – 315 cm: total sedge decomposed peat rich in mineral matter

315 – 327 cm: clay

2.2. Dating

The chronology is based on twelve ^{14}C dates (Table). No suitable terrestrial remains were found, so the main material was bulk. We use Bchron package in the R for the age model (Haslett and Parnell, 2008; R: The R Project for Statistical Computing). The average sedimentation rate is 12 years/cm.

2.3. Microcharcoal analysis

Microcharcoal analysis was made on pollen slides for the 78 samples of 6 ml volume, each sample containing one tablet of Lycopodium at 15853 spores. The diagram of the concentration of microcharcoal was made in the Tilia-Tilia Graph (Grimm, 2004) (Fig.).

3. Results

The objectives of the study determined subsampling from the core: sediments of the Bronze Age and of the turn of the Eras were studied in detail (each cm); the rest of the profile was subsampled with an interval of 10 cm. We counted ca. 500 terrestrial pollen in each of 78 samples and identified 185 palynological taxa. The bottom sample had an unrepresentative amount of pollen. Only terrestrial pollen (AP + NAP) were used for the main percentage calculations. For the *Cyperaceae*, aquatics, spores of mosses or pteridophytes percentage were calculated from the total sum. Local pollen zones (LPZs) were singled out by cluster analysis. The AP/NAP ratio indicates the predominance of forest vegetation. But large proportion of NAP (up to 65%) at the base of the sequence is more typical of semi-open landscapes.

LPZ1 (4.6-4.4 cal. ka BP) reflects the beginning of swamping; deciduous forests alternated with meadow there (Fig.). The predominance of *Pinus* pollen (up to 27%) is associated with an openness increase and long distance wind transport, rather than with real participation in the local forest. The composition of the forests was formed by *Fagus*, with *Carpinus*, *Corylus*, *Tilia*, a small amount of *Acer* and *Prunus*, in some places with wild *Vitis*. Vast open spaces are identified by the abundance of Asteraceae, Cichoriaceae and Poaceae, many Caryophyllaceae, Apiaceae, *Scabiosa*, *Centaurea jacea*. *Hippophae rhamnoides* L. are associated with forest edges. Weak human impact is suggested by the presence of *Arctium* and *Cardus*.

In LPZ2 (4.4-3.2 cal. ka BP), the decreasing *Pinus* and increasing *Fagus* (30-52%) mark this phase as start of reforestation. The value of *Tilia* falls, but *Carpinus*, *Alnus*, *Ulmus*, *Quercus*, *Betula* and *Fraxinus excelsior* L. rise; *Prunus*, *Pterocarya*, and *Juglans* are occasionally found. A lot of open and edge forest areas are identified by the *Hippophae* and *Spiraea*, even *Daphne* indicates lightening of the forest. *Artemisia* increases; Poaceae, Chenopodioidae are constantly present; Cichoriaceae, Rosaceae, and Apiaceae have several peaks. An increase in pastoral pressure is suggested by *Plantago lanceolata* (max), *Rumex acetosa*, *Urtica* and *Cannabis*; Cerealia pollen appears frequently.

Starting from LPZ3 (3.2-2.6 cal. ka BP), the stage of the minerotrophic swamp ends and *Sphagnum* mosses appear, it becomes more favorable for *Alnus* along the swamp periphery. The forest becomes more closed: *Fagus* reaches 57%, *Carpinus* 15%, *Ulmus*, *Corylus* and *Vitis* increase, but *Quercus* decreases; *Picea*, *Prunus*, *Pterocarya*, *Juglans*, *Castanea* are common. The NAP composition has the same dominants, but the diversity decreases. The anthropogenic markers are *Plantago lanceolata*, *Urtica*, Brassicaceae, singly *Cerealia*.

In LPZ4 (2.6-2.1 cal. ka BP), *Fagus* predominates (37-52%), *Alnus* reaches 30%, especially in *Sphagnum* interlayer, but *Carpinus* gradually decreases, dark conifers disappear, and the diversity of broad-leaved trees declines. The NAP composition shows insignificant changes, only *Artemisia* and *Thalictrum* increase. *Plantago media*, *P. lanceolata*-type, and *Urtica*,

Table. Dating of Tarskoe swamp.

N	Deth (cm) mean	Lab nr. Ki	Age BP	Median Probability	Age BP 2 σ
1	25	19688	1320 +/- 30		653-707
2	50	19689	1920 +/- 40	1835	1730 - 1939
3	75	19690	1880 +/- 80	1795	1687 - 1993
4	100	19691	2160 +/- 70	2152	1992 - 2335
5	125	19692	2329 +/- 40	2346	2302 - 2469
6	150	19693	2340 +/- 40	2356	2305 - 2491
7	175	19694	2750 +/- 50	2844	2759 - 2954
8	200	19695	2930 +/- 40	3081	2960 - 3183
9	225	19696	2980 +/- 40	3155	3003 - 3252
10	250	19697	2730 +/- 50	2827	2753 - 2939
11	275	19698	3490 +/- 50	3761	3631 - 3896
12	300	19699	4010 +/- 80	4492	4243 - 4656

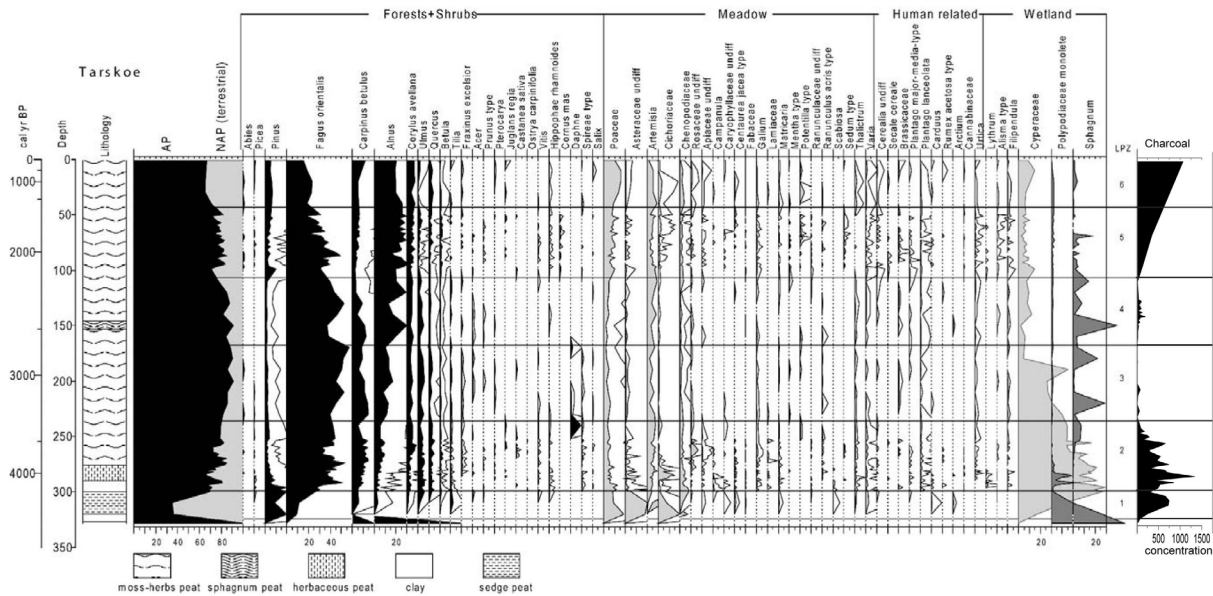


Fig. Pollen and microcharcoal diagram of Tarskoe swamp.

infrequent *Cerealia*, Brassicaceae, *Arctium* and *Rumex acetosa* are associated with humans.

LPZ5 (2.1-1.8 cal. ka BP) reflects the initial gradual increase in open areas. *Fagus* and *Carpinus* decrease, but shares of *Pinus*, *Betula*, dark coniferous, shrubs, and lianes rise. The Poaceae and diversity of meadow grasses increase; the *Secale* curve appears.

In LPZ6 (1.8 cal. ka BP – present), forest area continues decreasing or becomes sparser. *Fagus* noticeably reduces up to 15%, and then *Alnus* to 18%, with a slight rise in *Carpinus*, *Corylus*, and *Quercus*. Besides, value of distant pollen (*Pinus*, *Picea*, and *Abies*) increases. Open areas increase, as demonstrated by Poaceae (max), Cichoriaceae and Asteraceae. The pasture indicators include *Plantago lanceolata*, *Rumex acetosa*, and *Cardus*; and the agricultural ones - *Cerealia* and *Secale*.

The maximum concentration of microcharcoal in the section is noted in LPZ2(1500 units), the next highest value is observed in LPZ6 a little more than 1000 units. LPZ3 and LPZ4 has a very low concentration of microcharcoal.

4. Discussion and conclusions

At the beginning of the formation of the swamp about 4.6 cal. ka BP, the landscape of the foothills of the central part of the North Caucasus was semiopen, with a large proportion of meadows than today, perhaps this kind of landscape was under the influence of previous human activity, precisely of agriculture Maikop culture in the Bronze Age. This short-term episode is gradually replaced by broad-leaved forests, with a predominance of beech. Among the local transformations the replacement of Cyperaceae to *Alnus* and the appearance of *Sphagnum*, indicates a change in the type of water supply of the swamp. The greatest value of microchrcoal is most likely associated with anthropogenic activity, and is almost always synchronous with the appearance of cultivated cereals pollen. The first peak of microcharcoal (LPZ2) is

associated with an increase in diversity among a group of human-related grasses and appearance of cultivated cereals pollen about 4.3 cal. ka BP; the second peak (LPZ6) realeted with the increases of quantity of weeds and significantly increases the proportion of cultivated cereals pollen.

Acknowledgments

Radiocarbon dating of sediments by the Russian Science Foundation, grant nr.19-18-00406, pollen analysis by the Russian Foundation for Basic Research, grant nr. 20-35-90014.

Conflict of interest

The authors declare no conflict of interest.

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 R: The R Project for Statistical Computing. URL: <https://www.r-project.org/>