Short communication

ISSN 2658-3518
LIMNOLOGY FRESHWATER BIOLOGY
www.limnolfwbiol.com

Late Holocene vegetation history of the Western Caucasus inferred from high-resolution pollen record from Lake Karakel

Chepurnaya A.A.[1]*, Novenko E.Y.[1,2], Aleksandrin M.Y.[2]

[1] *Lomonosov Moscow State University, 1 Leninskiye gory, Moscow, 119991, Russia*
[2] *Institute of Geography RAS, 29 Staromonetniy lane, Moscow, 119017, Russia*

ABSTRACT. The paper presents a new paleoecological evidence for the last 2200 years based on high resolution pollen record and detail radiocarbon dating, obtained from Lake Karakel (Teberda River valley, Western Caucasus). The obtained results showed that vegetation changes from 2200 to stage 1200 cal, yr BP occurred under a climate warming and increase of humidity. The Medieval Climatic Anomaly-MCA (ca. 1200-880 cal. yr BP) was characterized in this region by the predominance of broadleaved forests. The MCA was followed by a cold interval of the Little Ice Age (ca. 880-120 cal yr BP) that marked by expansion of pine, spruce and fir forests to the lower altitude the present time.

Keywords: Caucasus, palynology, Teberda, paleolandscapes, reconstruction

1. Introduction

The Late Holocene vegetation and climate history in mountainous regions are characterized by high temporal and spatial variability (PAGES 2k Consortium, 2017), therefore regional paleoenvironmental reconstructions may be useful in unraveling the ecosystem response to ongoing climatic change. In this case the proxy records revealed from mountainous lakes holds a great potential for paleovegetation and climate studies.

The present study is focused on the mid-altitude Lake Karakel is located in the Teberda River valley, Western provinces of Great Caucasus. The studies of mountain lakes in the Western Caucasus began by research group from the Institute of Geography of Russian Academy of Science about ten years ago exploring Lakes Karakel and Donguz-Orun (Chepurnaya, 2014; Solomina et al., 2014). The previous pollen record from Lake Karakel covered the entire Holocene with a hiatus of *ca.* 2000 years in the middle Holocene. Annually laminated sediments in Lake Donguz-Orun near Terskol village, Kabardino-Balkaria cover <1000 years (Alexandrin et al., 2018). Despite the large amount of the obtained pollen data, the Late Holocene environmental history remained poorly understood.

Our study provides new paleoecological evidence for the last 2200 years based on high resolution pollen record supported by detail radiocarbon dating, obtained from Lake Karakel.

2. Materials and methods

Lake Karakel (N 43 26’ 12,13” E 41 44’ 34,72”) at altitude 1335 m a.s.l. (above sea level) is dammed by an old moraine in the Teberda River valley. The lake is 6-8 m deep and occupies an area of 140x280 m. The lake is surrounded by a sparce pine forest.

Three overlapped lacustrine sediment cores up to 180 cm long retrieved from Lake Karakel in 2010 and 2016. The present study is focused on the 76 cm long core obtained in 2016 that includes the uppermost dark brown to black organic reach sediments.

Radiocarbon dates from the core obtained in 2010 together with the new ones were used for creating of the age-depth model. In total 10 AMS radiocarbon dates provide the chronological control for the sedimentation rate. Radiocarbon dating was performed in the Laboratory of radiocarbon dating and electronic microscopy at the Institute of Geography (Russian Academy of Science, Moscow, Russia) and the Center for Applied Isotope Studies at University of Georgia (USA). The ^{14}C dates were calibrated using the program Calib 8.2, the calibration dataset Intcal20 (Reimer et al., 2020). Age-depth models were constrained using the Bayesian-based algorithm Bacon in the R language environment.

The sediment core was subsampled for pollen analysis with 1 cm interval. Samples (1 cm^3) were prepared following modified method by Grichuk and Zaklinskaya (1948). Calculation of pollen percentages

*Corresponding author.
E-mail address: a_che@bk.ru (A.A. Chepurnaya)

Received: July 1, 2022; ***Accepted:*** July 21, 2022;
Available online: September 02, 2022

was based on the total terrestrial pollen sum, i.e. arboreal pollen (AP) plus non-arboreal pollen (NAP) without aquatic plants and spores. A minimum of 700 pollen grains per sample were counted (AP + NAP). Pollen diagram was constructed using the programs Tilia and TGView.

3. Results and discussion

According to an age-model based on the radiocarbon dates the uppermost 76 cm of the sediment sequences was formed about 2200 cal yr BP (Subatlantic period of the Holocene) with the accumulation rate of 0.22-0.23 mm/year.

The pollen diagram for Lake Karakel was divided into 7 local pollen assemblage zones (LPAZ), corresponding to the main phases of vegetation development (Fig.).

LPAZ 1 (76-65 cm; 2200-2000 cal yr BP). Pollen assemblages are characterized by a relatively high NAP content (up to 35%) dominated by *Poaceae* and *Asteraseae (Artemisia)*. Pollen values of arboreal taxa increase from 65 to 90% towards the upper part of the zone. *Pinus* pollen is the most abundant. The permanent components of pollen assemblages is *Alnus, Corylus* and *Betula* sect. *Albae*. Pollen of broadleaved species (*Quercus*, *Carpinus*, *Fagus*) and coniferous trees such as *Abies* and *Picea* occur in a minor quantity. Pollen of light demanded plants as *Hippophaea* and *Helianthemum sp.* were registered.

Pollen assemblages were obviously influenced by vegetation of several types of landscapes. Meadows were most likely confined to the southern, south-eastern and south-western slopes of the Teberdy River valley. The slopes of the northern and adjacent expositions were occupied by broad–leaved forests mainly of

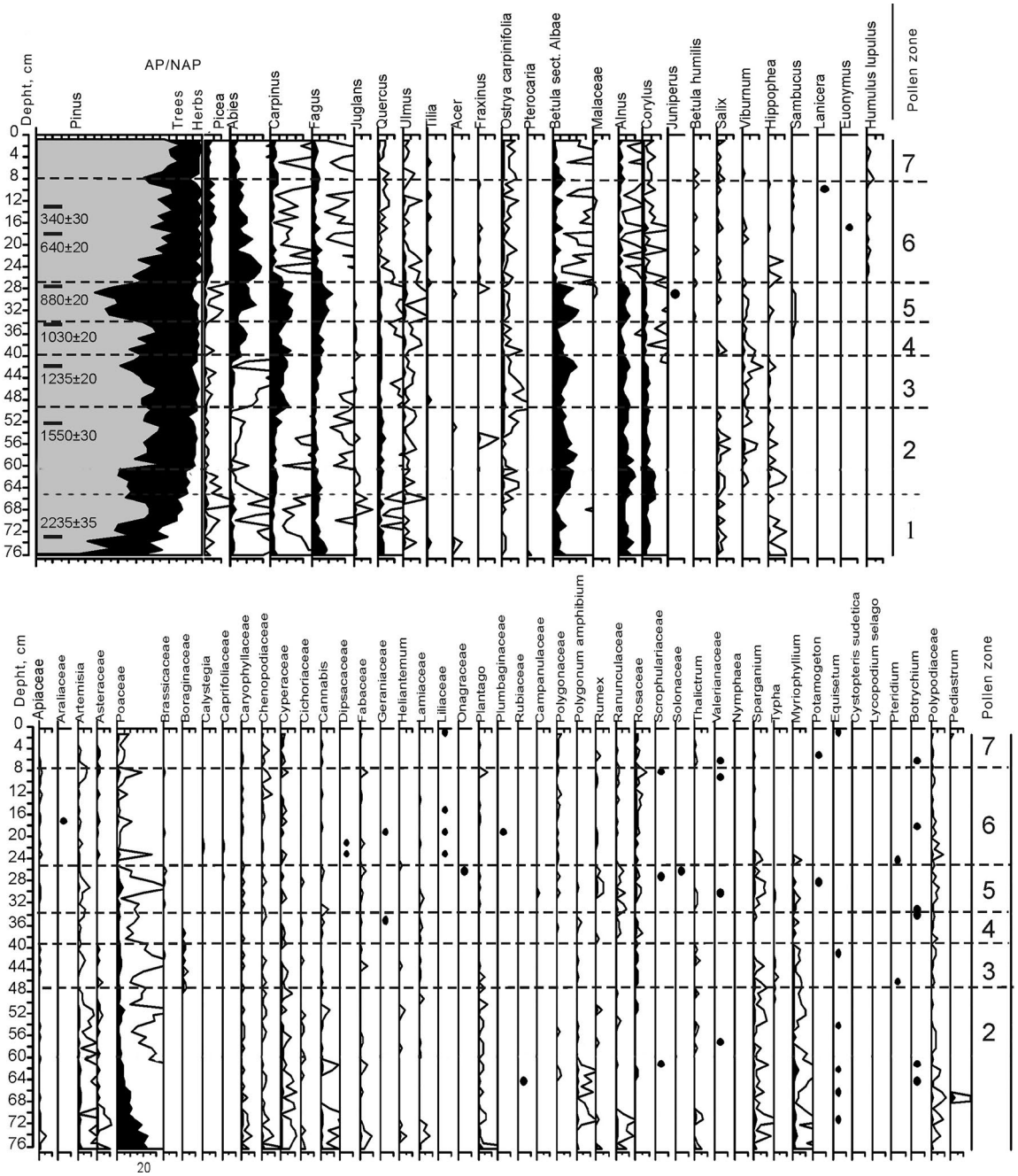

Fig. Pollen diagram of Karakel Lake deposits (AP + NAP = 100%). Age, C14 years BP.

beech and oak with the participation of coniferous species - spruce and fir. Besides, composition of pollen assemblages reflects an intrazonal vegetation, which included *Pinus, Betula, Salix* and *Hippophaea*, which settled mainly along the river bank and outflow of the ravine proluvium, affected by cold air flows descending from glacial covers and mountain ranges (Bagrova and Drozdov, 2010).

LPAZ 2 (65-49 cm, 2000-1500 cal yr BP). AP value increased from 80% in the lower part of the zone to 90% in its middle and upper parts. *Pinus* pollen still dominates in the AP group (50-70%), however the noticeable peaks of *Betula, Alnus* and *Corylus* pollen were detected. Broadleaved species (*Carpinus, Quercus, Fagus, Ulmus*) are not abundant, *Picea* and *Abies* pollen values a little declined. *Hippohpeae* pollen became more frequent at the depth between 62 and 60 cm.

Changes in pollen assemblages indicated an afforestation of treeless areas. A rather high content of birch pollen in the spectra and the presence of *Hippophaea* pollen, which are early succession plant species, may indicate the active catastrophic geomorphological processes, such as avalanches, landslides, etc.

LPAZ 3 (49-40 cm, 1500-1200 cal yr BP). The zone was marked by first peak of *Carpinus* curve and increase of *Fagus* pollen values. AP value grew to 95%. Pollen assemblages revealed a change in the composition of broadleaved forests with the leading role of *Carpinus* and *Fagus*. The proportion of *Corylus* in the undergrowth declined, suggesting a greater crown density of forests compared to the previous stage.

LPAZ 4 (40-34 cm, 1200-1000 cal yr BP). *Abies* pollen value increases from 1 to 10%, The proportion of *Pinus* raised to 75%, while *Carpinus* and *Fagus* pollen value decrease to a few percent.

LPAZ 5 (34-27 cm, 1000-880 cal yr BP) Assemblages are characterized by noticeable peaks of *Abies* (up to 20 %) and *Fagus* (up to 10%) curve and second peak of *Carpinus* (up to 13%), while *Pinus* pollen value decreased from 75 to 50%.

Pollen assemblages of the LPAZ 4 and 5 suggest a successive development of coniferous-broadleaved forest belt with high abundance of *Carpinus, Fagus* and *Abies* which could be coincided with the Medieval Climatic Anomaly (MCA, ca. 900-1350 C.E. (common era); PAGES 2k Consortium, 2017).

LPAZ 6 (27-8 cm, 880-120 cal yr BP) There is a noticeable decrease in *Carpinus* and *Fagus* pollen percentages with increase in *Pinus, Abies* and *Picea* pollen values. The proportion of NAP group decreases to a few percent. Probably, climatic cooling of the Little Ice Age (LIA, AD 1450–1850 C.E.; PAGES 2k Consortium, 2017) encouraged the downward movement of beech-fir forests with the participation of *Pinus,* and *Picea,* typical for modern high-altitude woodlands near the timberline.

The previous studies of pollen and chemical element composition (Br) of the sediment sequences of the Karakel Lake revealed three LIA cooling phases in 1250-1400, 1500-1630 and 1750-1880 C.E. (Chepurnaya, 2014; Solomina et al., 2014).

Comparison of obtain data with pollen records from the Rybnoye Lake (Kvavadze and Efremov, 1996), located in 50 km north-west from the Karakel Lake at altitude 2156 m a.s.l. showed a similar pattern of broadleaved pollen dynamics and rather synchronous phase of the MCA and LIA.

LPAZ 7 (8-0 cm, 120 cal yr BP – resent). Pollen value of *Picea* and *Abies* decrease to a few percent, while *Carpinus* and *Fagus* pollen value increased. *Pinus* and *Betula* pollen values increased noticeably indicating and occurrence of pine and pine-birch forests on moraine ridges in river valleys and human induced vegetation disturbance.

4. Conclusions

Palynological analysis and radiocarbon dating of sediments fom Lake Karakel allow us to discussed vegetation dynamics of the Western Caucasus during the sub-Atlantic stage of the Holocene. Vegetation changes from 2200 to stage 1200 cal. yr BP occurred under the climate warming and increase of humidity. The Medieval Climatic Anomaly (ca. 1200-880 cal yr BP) was characterized in this region by the predominance of broadleaved forests. The MCA was followed by a cold interval of the Little Ice Age (ca. 880-120 cal yr BP) that marked by expansion of pine, spruce and fir forests to the lower altitude the at present time.

Acknowledgements

This work was performed in the framework of the State Task No. 0127-2019-0008 «Markers of natural events in high-resolution sedimentation paleoarchives»

Conflict of interest

The authors declare no conflict of interest.

References

Alexandrin M.Y., Darin A.V., Kalugin I.A. et al. 2018. Annual sedimentary record from Lake Donguz-Orun (Central Caucasus) constrained by high resolution SR-XRF analysis and its potential for climate reconstructions. Frontiers in Earth Science 6: 158. DOI: 10.3389/feart.2018.00158

Bagrova T.N., Drozdov V.V. 2010. Influence of large-scale atmospheric circulation on climatic parameters of the Western Caucasus (Teberdinsky State Reserve). Uchenye Zapiski Rossiyskogo Gosudarstvennogo Gidrometeorologicheskogo Universiteta [Scientific Notes of Russian State Hydrometeorological University] 13: 52-63. (in Russian)

Chepurnaya A.A. 2014. Dynamics of vegetation cover in the Late Holocene in Lake Karakel – Teberda Valley area (according to palynological data). Izvestiya Rossiiskoi Akademii Nauk. Seriya Geograficheskaya [Proceedings of the Russian Academy of Sciences. Series Geography] 2: 84-95. (in Russian)

Grichuk V.P., Zaklinskaya E.D. 1948. Analiz iskopayemykh pyl'tsy i spor i yego primeneniye v paleogeografii [Fossil pollen and spores analysis and its implementation in paleogeography]. Moscow: OGIZ. (in Russian).

Kvavadze E.V., Efremov Y.V. 1996. Palynological

studies of lake and lake-swamp sediments of the Holocene in the high mountains of Arkhyz (Western Caucasus). Acta Palaeobotanica 36(1): 107-119.

Pages2k Consortium. 2017. A global multiproxy database for temperature reconstructions of the Common Era. Scientific data 4.

Reimer P.J., Austin W.E., Bard E. et al. 2020. The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0–55 cal kBP). Radiocarbon 62(4): 725-757. DOI: 10.1017/RDC.2020.41

Solomina O.N., Kalugin I.A., Darin A.V. et al. 2014. The implementation of geochemical and palynological analyses of the sediment core of Lake Karakyol for reconstructions of climatic changes in the valley of Teberda River (Northern Caucasus) during the Late Holocene: possibilities and restrictions). Voprosy Geografii [Questions of Geography] 137: 234-266. (in Russian).