Short communication

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

Reflection of climate events in deposits of Belarusian Lakes at the Middle-Late Holocene transition

Zernitskaya V.P.[1], Vlasov B.P.[2*]

[1] Institute for Nature Management of the National Academy of Sciences of Belarus, Ul. F. Saryny 10, 220076, Minsk, Belarus
[2] Belarusian State University, Pr. Nezavisimosti 4, 220050, Minsk, Belarus

ABSTRACT. The analysis of the proxy archives from lake sediments made it possible to install the natural indicators the Holocene into three stages at 8200 and 4200 cal. yr. BP, the timing is consistent with that seen in the Greenland ice-core data. We studied proxy archives based on pollen-stratigraphic, sedimentological, radiocarbon and isotopic dates.

Keywords: Holocene, lacustrine deposits, pollen analysis, isotopes data

1. Introduction

According to the International Chrono-stratigraphic Chart the Holocene Epoch/Series is formally subdivided into three subseries/stages: the Greenlandian – a lowermost stage with a lower boundary dated at 11700 cal. yr. before present (B.P) .P.; the Northgrippian – the Middle Holocene stage dated at 8200 cal. yr. B.P.; and the Meghalayan – an uppermost stage with a date of 4200 cal. yr. B.P. (Head and Gibbard, 2015; Walker et al., 2018). In the Chronostratigraphic chart of Belarus, the Holocene (H1) is also defined as an Epoch/Series within the Quaternary System/Period, but corresponds to the Lower Holocene subseries, which in turn characterized by Sudoble horizon (sd) or deposits of the unfinished Sudoble Interglacial (Zernitskaya et al., 2005). The Sudoble horizon (Lower Holocene) is represented by five layers (pollen-stratigraphy) that accumulated in the Holocene periods according to J. Mangerud et al. (1974). Nevertheless, in lacustrine sediments the natural markers that record specific climate events were identified at 8200 and 4200 cal. yr. B.P. (lithological, palynological, oxygen and carbon isotopes).

2. Materials and methods

The objects of the study were 10 lakes located in various regions of the country. Lakes Lozoviki (first in print as Lake Bezymiannoe, Makhnach et al., 2004), Naroch, Okono, Mezhyzhol and Teklits are situated in zone of the last glaciation, and Lakes Bobrovichskoye, Dvorischanskoye, Sergeevskoye, Staroje and Sydoble are outside it. The geological material of the lake sediments was obtained employing coring through ice.

The samples were taken every 2–4 cm, volume 3 cm^3 for pollen and isotope analysis. The isotope ($\delta^{18}O$, $\delta^{13}C$) investigation were carried out at the Institute of Geology (Research and Production Center for Geology), Belarus (profiles Lozoviki, Naroch, Okono, Teklits, Sergeevskoye), at the Nature Research Centre, Lithuania (profile Staroje), and radiocarbon dating (^{14}C) – at the Institute of Geology (IGS, Minsk), at the Institute of Environmental Geochemistry of the National Academy of Sciences of Ukraine (Ki, Kyiv); AMS ^{14}C dates – at the Poznan Radiocarbon Laboratory (Poland) and at the Institute of Geography of the Russian Academy of Sciences (IGAN, Moscow) (Makhnach et al., 2004; 2009; Zernitskaya et al., 2010; 2019; Zernitskaya and Vlasov, 2019).

3. Results and discussion

Based on the results of loss-on-ignition survey, some main lithostratigraphic units have been identified in deposits of carbonate reservoirs. The lower part of the sections is represented by lake white-grey marls formed between 11700/11500–8300/8200 cal. yr. B.P. Above of level 8300/8200 cal. yr. B.P., marls give way silty marls, layers of yellowish grey carbonate sand can occur and organic matter (OM) increases. In the time range from 7900 to 4400/4000 cal. yr. B.P. the carbonate sapropels were formed, which has been overlain by organic or silts sapropels (Lakes Lozoviki, Naroch, Okono, Teklits and Sergeevskoye).

*Corresponding author.
E-mail address: vlasov@bsu.by (B.P. Vlasov)

Received: May 26, 2022; ***Accepted:*** August 12, 2022;
Available online: September 02, 2022

In the North Greenland ice-cores, the event at 8200 cal. yr. B.P. was marked by negative shift in the oxygen isotope records, reflecting a cooling climate, which in various regions of Europe was characterized by either cold-dry winters and wet summer, or cold and snowy winter conditions (Veski et al., 2004; Ojala et al., 2008; Magny et al., 2012). The signal of this short-term cooling is clearly visible in the Belarusian isotope records as negatory peaks of $\delta^{18}O$ between 8300–8000 cal. yr. B.P. At the same time, the quasi-synchronous shifts of $\delta^{13}C$ towards lower values were registered (8400–7900 cal. yr. B.P.), as well as increased OM (Lakes Lozoviki, Okono, Teklits and Sergeyevskoye) and/or mineral fraction in carbonate sediments (Lakes Staroye, Teklits and Bobrovichskoye). These data indicate an increase in humidity and an intensification of erosion processes leading to the influx of detrital material into the lakes. In the pollen spectra, the cold event was fixed by a drop in the pollen values of thermophilic trees (mainly *Ulmus* and *Corylus*) and an increase of content *Picea* in profiles lying in the north and in the center of the country and *Betula* and *Pinus* pollen – in the south region.

The event ca. 4200 cal. yr. B.P. was a new impulse to cooling and increasing humidity. During 4200–4000 cal. yr. B.P., the second post-optimal level of decrease of thermophilic trees pollen was established, simultaneously with the increase in the share of *Picea* pollen (profiles: Lozoviki, Naroch and Sergeyevskoye). The decrease in the isotopic composition of oxygen and carbon in the sediments of Lake Naroch began ca. 4200 cal. yr. B.P., and the minimum values were obtained in the range from 3400 to 2700 cal. yr. B.P. (Fig.), which was explained by the acceleration of water exchange due to cooling, reduced evaporation and increased precipitation (Zernitskaya et al., 2010).

4. Conclusions

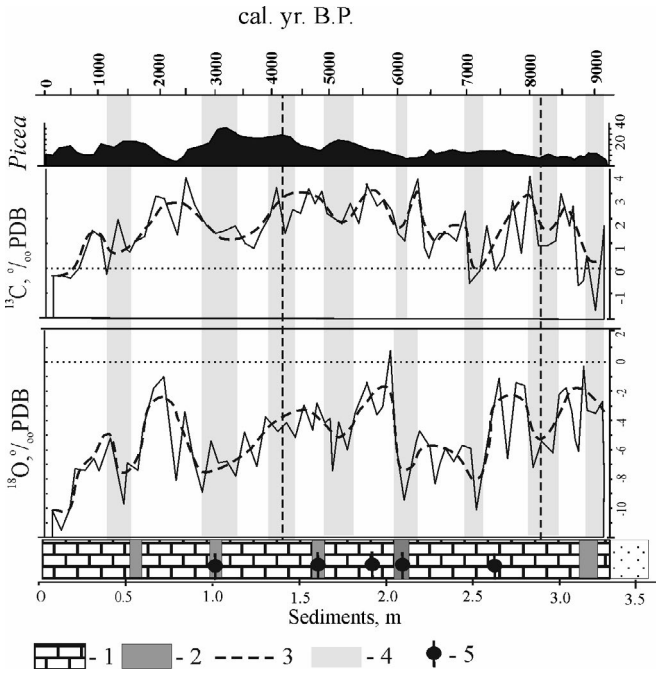
A comparison of $\delta^{18}O$, $\delta^{13}C$ ratios in bulk carbonates with pollen spectra and lithological compositions in lacustrine deposits of Belarus showed that the episodes of cooling in the Holocene were accompanied by an increase in humidity. These episodes often were coincided with the rise of lake levels, and were identified at 11400–11000, 9400–9000, 8200–7900, 7200–7000, 6400–6000, 5500–5200, 4200–4000, 3400–2700, 1500–1200 and ca. 800 and 500 cal. yr. B.P. (Zernitskaya and Vlasov, 2019).

Conflict of interest

The authors declare no conflict of interest.

References

Head M.J., Gibbard P.L. 2015. Formal subdivision of the Quaternary System/Period: past, present, and future. Quaternary International 383: 4-35. DOI: 10.1016/j.quaint.2015.06.039



1 – carbonate gyttja; 2 – layers enriched in organic matter; 3 – averaged isotope curve; 4 – cooling episodes; 5 – ^{14}C dating

Fig. Correlation of isotope records and Picea pollen amount in Naroch lake carbonate sediments.

Magny M., Joannin S., Galop D. et al. 2012. Holocene palaeohydrological changes in the northern Mediterranean borderlands as reflected by the lake-level record of Lake Ledro, northeastern Italy. Quaternary Research 77(3): 382-396. DOI: 10.1016/j.yqres.2012.01.005

Makhnach N., Zernitskaja V., Kolosov I. 2009. Stable isotopes of carbon and oxygen and spore-pollen spectra in Late Glacial-Holocene carbonate sediments of Lake Sergeevskoe (Belarus). Litosfera [Lithosphere] 1(32): 103-114. (in Russian)

Makhnach N., Zernitskaja V., Kolosov I. et al. 2004. Stable oxygen and carbon isotopes in Late Glacial-Holocene freshwater carbonates from Belarus and their palaeoclimatic implications. Palaeogeography, Palaeoclimatology, Palaeoecology 209(1-4): 73-101. DOI: 10.1016/j.palaeo.2004.02.019

Mangerud J.A.N., Andersen S.T., Berglund B.E. et al. 1974. Quaternary stratigraphy of Norden, a proposal for terminology and classification. Boreas 3(3): 109-126. DOI: 10.1111/j.1502-3885.1974.tb00669.x

Ojala A.E., Heinsalu A., Kauppila T. et al. 2008. Characterizing changes in the sedimentary environment of a varved lake sediment record in southern central Finland around 8000 cal. yr BP. Journal of Quaternary Science 23(8): 765-775. DOI: 10.1002/jqs.1157

Veski S., Seppä H., Ojala A.E. 2004. Cold event at 8200 yr BP recorded in annually laminated lake sediments in eastern Europe. Geology 32(8): 681-684. DOI: 10.1130/G20683.1

Walker M., Head M.J., Berkelhammer M. et al. 2018. Formal ratification of the subdivision of the Holocene Series/Epoch (Quaternary System/Period): two new Global Boundary Stratotype Sections and Points (GSSPs) and three new stages/subseries. Episodes 41(4): 213-223. DOI: 10.18814/epiiugs/2018/018016

Zernitskaya V.P., Makhnach N.A., Kolosov I.L. 2010. Stable carbon and oxygen isotopes and spore-pollen spectra in Middle – Upper Holocene carbonate sediments from lake Naroch. Vestnik Brestskogo universiteta. Seriya 5. Khimiya. Biologiya. Nauki o Zemle [Vesnik of Brest University. Series 5. Chemistry. Biology. Earth Sciences] 1: 88-98. (in Russian)

Zernitskaya V.P., Matveyev A.V., Makhnach N.A. et al. 2005. Stratigraphic scheme of the Late Glacial and Holocene deposets of the Belarus. Litosfera [Lithosphere] 1(22): 157-165. (in Russian)

Zernitskaya V.P., Novenko E.Yu., Stančikaite M. et al. 2019. Environmental changes in the Late Glacial and Holocene in the south-east of Belarus. Doklady Natsional'noy Akademii Nauk Belarusi [Reports of the National Academy of Sciences of Belarus] 63(5): 584-596. (in Russian)

Zernitskaya V.P., Vlasov B.P. 2019. Climate records of Late Glacial and Holocene of Belarus. In: Vth All-Russian Conference with international participation "Holocene Ecosystem Dynamics" (on the occasion of the 100th anniversary of L.G. Dinesman), pp. 107-108.