Short communication

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Paleolimnological study of Lake Uchum (South Siberia, Russia)

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ABSTRACT. In the course of this work, the bottom sediments of Lake Uchum located in the Minusinsk depression, in the south part of the Krasnoyarsky kray were studied. The subjects of the investigation were the photosynthetic pigments, alkenones, and valves of diatoms extracted from the core of bottom sediments. We discovered the presence of characteristic photopigments of green algae, and, in addition to them, the okenon of a carotenoid specific to purple sulfur bacteria, as indicator of meromixia. The presence of okenon in the bottom sediments of the lake is irregular, which likely indicates the instability of the lake hydrological regime in the past. Alkenones in the lake bottom sediments demonstrate a dependence on the physicochemical conditions of the lake water. The found diatom frustules were often strongly decayed and belong to the same species along the core. However, inclusions of well-preserved frustules were also found, which were most likely reworked.

Keywords: HPLC, Paleolimnology, paleoproxies, pigment analysis, diatom analysis, alkenones

1. Introduction

Meromictic lakes are the archives of the various proxies that can provide a valuable data about lake past (Boehrer & Schultze, 2008). Lakes Shira and Uchum are one of well-studied meromictic lakes in South Siberia (Rogozin et al., 2018). Bottom sediment of these meromictic lakes have undisturbed thin-layer structure that allow to reconstruct the paleo-history of the lake and region. Among the paleo-proxies a most vide used are the studies of fossil photopigments, diatom shells and alkenones. Photopigments are usually connected to the definite group of phototrophs and allow to compare they diversity and production in the past (Bianchi, Canuel, 2011).

The shape of diatom frustules allows to determine its species, also diatom is very sensitive to environmental condition, therefore analysis of fossil shells may reconstruct changes in the lake ecosystem (Flower, Ryves, 2009).

Alkenones are the long-chain hydrocarbons that produces only by several species of Haptophyta algae. They ration of factions with different quantity of double-bond correspond with environmental condition such as temperature and salinity. Its wildly used for reconstruction of paleotemperature for the oceans, and it also can be used for inland waterbodies (Randlett et al., 2014; Radle, et al, 1989).

Research of the paleo proxies of bottom sediments from Lake Uchum may provide data for further understanding of the past of ecosystem of Minusinsk depression.

2. Materials and methods

Lake Uchum (55.05.670 N, 89.43.390 E) is a meromictic lake is located in the North Minusinsk depression, 30 km south of the city of Uzhur, on the territory of the Uzhursky District of the Krasnoyarsky kray. Its reservoir has an oval shape of 1.5 × 4 km with a surface area of about 4 km^2 and a maximum depth of 7.9 m (2015). The ionic composition of water is sulfate-chloride, sodium-potassium (Krivosheev et al, 1990). The salinity in the upper layers of mixolimnion during the summer stratification in 2015 and 2016 was about 24 g l^{-1} and 34 g l^{-1} in the bottom layers. Bottom sediments of the lake have a mostly undisturbed layered structure, which makes the reservoir a valuable object for conducting paleo-study.

In this work, the core of the bottom sediments of Lake Uchum, sampled in the summer of 2015, was studied. This core was analyzed for the pigment composition, diatom frustules and long-chain hydrocarbons - alkenones.

Extraction and analysis of photosynthetic pigments was performed by the modified method of Wright et al. (1991), which was also used in studies of Lake Shira.

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Diatom frustules analysis was performed by standard method (Bolobanshchikova, et al., 2018) and identified with reference book.

Alkenone study was performed by the method described Randlett et al (Randlett, et al., 2014). Analysis was carried out by the GH-MS chromatograph Agilent 7890/5975C. Identification of peaks was made according to, the data from Jaraula et al. (2010)

3. Results and discussion

Chromatographic analysis of photopigments extracted from bottom sediments revealed that they contain several main carotenoids originated from different group of algae. Among them are alloxanthin (*Cryptophyta*), Loraxanthin (green algae), Lutein (green algae), zeaxanthin (*Cyanobacteria*) and the carotenoid of purple sulfur bacteria – okenone. Pigment composition of the bottom sediments shown below (Fig. 1) indicates that the lake underwent significant changes throughout the formation of the core, which affected its phototrophic communities. The dynamics of okenone, paleoproxy of the presence of hydrogen sulfide in the bottom layers of the lake, varies from 15 to 450 mkg g^{-1}. In the samples from 200-270, 320-350 and 460-520 cm, the concentration of okenone reaches the minimum values (approx. 1-3 mkg g^{-1}) and in the area 720-790 disappears completely. This likely indicates a weakening of the hydrogen sulfide zone in the monimolimnion of the lake during that period (Overmann, 2008). Carotenoids of green sulfur bacteria (chlorobactene and isorenieratene) are absent in all samples of the core, which is presumably caused by unfavorable conditions for them.

Alkenones were discovered in bottom sediments of Lake Uchum in sufficient amounts. Based on the data obtained by gas chromatography, the unsaturation indices of the alkenone fractions Uk37, Uk'37, Uk38 and Uk3738 were calculated. The indices Uk37 and Uk'37 (reverse index Uk37) are changing according to the temperature increase in the last century. The indices Uk38 and Uk 3738 do not show any dependence on temperature, but instead show a controversial reaction to changes in salinity (lake level) (Bianchi,Canuel, 2011).

The species composition of diatoms found in the core turned out to be extremely poor. Diatoms were mostly found singly frustules, some of which cannot be identified even to the genus due to its decayed. This indicates unfavorable conditions for the preservation of diatoms. Diatoms are distributed unevenly. Thus, samples from 36 cm up to 44 cm are characterized by sharp increases in numbers *Epithemia sp., Nitzschia sp., Surirella sp*. (benthic, widespread in both fresh and salt bodies of water). *Cyclotella choctawhatcheeana* (planktonic, brackish-water, widespread species) was found at a depth of 41-42 cm. In addition, *Lindavia radiosa* (planktonic, freshwater, alpine and subalpine species) and *Staurosira sp.* (benthic, widespread in both fresh and salt bodies of water) also were well-preserved. The small amount of these frustules with their localization in separate layers likely evidences that they were reworked.

Obtained data suggest that lake underwent significant changes in water level during sedimentation of the sediments. The time span of the changes are closely corresponded with ones inferred from records of Lake Shira (Zykov, et al., 2012). This makes Lake Uchum a valuable object for future paleoclimate study of the region of South Siberia.

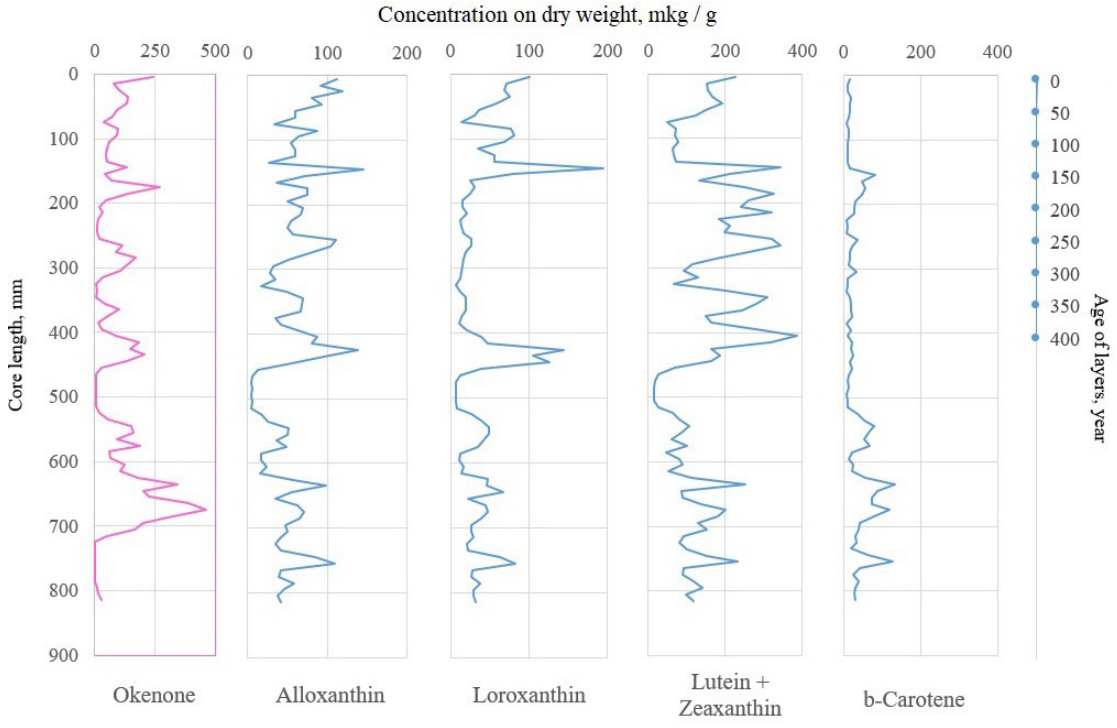

Fig.1. Distribution of carotenoids in the core of bottom sediments of Lake Uchum

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