Short communication

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A new approach to paleoreconstruction of Gusinoe Lake sediments: lipid biomarker analysis

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ABSTRACT. Lakes are important paleoenvironmental archives retaining abundant information due to their typical high sedimentation rates and susceptibility to environmental changes. Here, we present first results from lipid biomarker investigations of Gusinoe Lake sediments using gas chromatography (GC) and GC-mass-spectrometry. In total, 91 components were identified in the lipid fraction, including saturated, unsaturated, branched and hydroxy fatty acids, fatty alcohols, dicarboxylic acids, aldehydes, sterols and alicyclic compounds. The main lipid biomarkers and their ratios showed the contribution of bacteria, plankton and terrestrial higher plants to the organic matter of bottom sediments of Lake Gusinoe. The distribution of the carbon preference index (CPI) in the core of bottom sediments of Lake Gusinoe testifies to the transition from cold and dry (lower core layers) to warm and humid climatic conditions. This study illustrates potential of lipid biomarkers as paleoclimate and paleoenvironment proxies.

Keywords: Lake Gusinoe, bottom sediments, lipid biomarkers, fatty acids, paleoreconstruction

1. Introduction

Lake bottom sediments are natural archives, storing information about the evolution of the lake. They are an important source of data on the climatic, geochemical, and environmental conditions that existed in the catchment area and in the reservoir itself. Thus, lakes are important paleoenvironmental archives of short-term processes at local to regional scales. Currently, there are several approaches for paleoreconstruction of lake bottom sediments. One of them is the use of various paleoindicators, in particular lipid biomarkers. Features of the structure and biosynthesis of fatty acids and lipids served as the basis for their wide application as biomarkers for the assessment of the origin and transformation of organic matter (Hu et al., 2006; Holtvoeth et al., 2010). Furthermore, lipid biomarkers have been widely used to reconstruct paleoenvironments and changes in lacustrine systems (Ishiwatari et al., 2006; Arts et al., 2009; Ouyang et al., 2015). The aim of the current study was to determine paleoenvironmental changes reflected in lipid biomarkers in a bottom sediment in Lake Gusinoe (Western Transbaikalia, Russia).

2. Material and methods

The 54-cm-long column was taken in March 2018 in the middle of Lake Gusinoe. A 1.5 m corer invented at the State Oceanographic Institute (TG-1.5) was used for sampling bottom sediments. Lipid components were extracted in layers (every 3 cm) by the method of acid methanolysis in a HCl/methanol solution for one hour at 80°C. The chromatograms of acid methanolysis products of bottom sediments obtained in the continuous scanning mode were analyzed, using the standard NIST 11.L program of an AT-6890/5973N gas chromatograph (Pintaeva, 2019).

3. Results and Discussion

In total, 91 compounds were identified in lipid fraction of sediments. The major components of lipid fraction were saturated fatty acids (25.51-81.64% of total lipids), followed by fatty alcohols (13.44-54.12%), hydroxy fatty acids (3.15-18.72%) and monounsaturated straight-chain and branched fatty acids (0.97-20.64%). Also, dicarboxylic acids, aldehydes, sterols and alicyclic compounds are found as minor components.

Although most lipid biomarkers are non-specific, previous studies (Camacho-Ibar et al., 2003; Holtvoeth et al., 2010) have shown that some of the fatty acids, as well as their ratios, can provide information about the origin of organic matter in bottom sediments. The following markers exist for assessing the contribution of bacteria, plankton (phyto- and zooplankton) and terrestrial higher plants to the organic matter of

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bottom sediments (Camacho-Ibar et al., 2003): ΣBact = i15:0 + a15:0 + i17:0 + a17:0; ΣPlank = 16:1ω7 + PUFAs(20:5+20:4) + PUFAs(22:6+22:5); ΣTerri = 24:0 + 26:0 + 28:0 + 30:0. The marker evaluating the contribution of the bacterial community to bottom sediments ranged from 0.13 to 4.45% and decreased with depth. The plankton marker (0.08-1.77%) also decreased with the depth and was not detected deeper than 33 cm. The marker of terrestrial higher plants (3.49-23.46 %), on the contrary, tended to increase with the maximum at a depth of 39–42 cm.

One of the important indicators is carbon preference index (CPI), the ratio of even-over-odd numbered carboxylic compounds. CPI is used to reconstruct paleoclimate and paleoenvironment, including temperature, humidity and dominant sources of related lipids. The reconstruction of paleoclimatic archives via CPI derives from the variation of diagenesis and degradation rates with climatic conditions. Under dry and cold climates, microbial diagenesis and degradation of organic material are reduced, corresponding to a high CPI value, while the accelerated microbial diagenesis and degradation of organic matter result in a low CPI value under a wet and warm climate (Xie et al., 2004; Zhou et al., 2005). The CPI in the analyzed core increases with depth, which testifies to the transition from cold and dry (lower core layers) to warm and humid climatic conditions. It is possible that the deep layers of the column were formed in the period prior to 1862, when the sampling site was not yet flooded. This will be completely clear after dating, and the results obtained by the present time may be correlated with the history of the evolution of Gusinoe Lake.

4. Conclusions

This study illustrates the potential of lipid biomarkers as paleoclimate and paleoenvironment proxies. Lipid molecular proxies in combination with molecular distribution of n-alkanes, dD or D/H ratios, palynological studies, etc. can be applied to reconstruct the past precipitation, temperature and humidity. The results of this study show the compatibility of different lipid biomarkers in assessing the origin of organic matter.

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