Short communication

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The Lake Onego watershed: morphology of lakes and classification of the bottom sediments

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ABSTRACT. The data on the lake morphometry and sediment lithostratigraphy of the Lake Onego watershed were collected. The classification of lakes was carried out according to the genetic features of relief. Four types of the lakes have been identified for the catchment area. The structural features of lake basins and bottom sediments were determined for each type of lakes.

Keywords: Lake Onego, lake basins, morphometry, sediments, lithostratigraphy

1. Introduction

Lake Onego (61°42´ N, 35°25´ E; 33 m a.s.l.) is the second largest freshwater lake after Lake Ladoga located in Europe. The lake has a surface area of 10,000 km^2 and a catchment area of 53,000 km^2 (Fig.). The watershed has a well-developed hydrographic network including more than 6500 rivers and 9500 lakes. It has a total lake-surface area of 3500 km^2 and a lake-surface area density of 6.5%. Waterbodies differ in a variety of limnological characteristics including origin, morphology and sedimentation patterns, etc.

Structure of lake basins and bottom sediments relates to the local geologic and geomorphologic features and history. The catchment area and lake depression are located in the nortwest of the East European Platform on the border of the crystalline shield and the sedimentary plate (Fig.). During the Last Glacial Period, they were in the marginal flank of the glacier. The Onego Ice Lake (OIL) was formed in the lake depression in the Late Glacial. The proglacial lake extended beyond the resent watershed on the maximum stage of its development (Subetto et al., 2019; Zobkov et al., 2019).

2. Materials and methods

The waterbodies of the Lake Onego catchment area are divided into three groups (Molchanov, 1946): (1) lakes located in cracks and faults of hard-rock; (2) lakes located in depressions of sandy-clayey glacial deposits; (3) lakes located in the area of limestone and covered with sandy-clayey deposits. The first group correlates with tectonic lakes and is located within the boundaries of the crystalline shield. The second group corresponds to glacial lakes and is placed within the entire watershed. The third group correlates with karst lakes and is spread within the sedimentary plate. However, the complexity and ambiguity of the origin of basins determines the presence of a larger number of genetic types and subtypes. The diversity of the morphometric characteristics and sedimentation features reflects it (Potakhin et al., 2019).

The stratigraphy of Quaternary deposits of the Lake Onego depression is as follows (Saarnisto and Saarinen, 2001; Hang et al., 2019; Subetto et al., 2020; Belyaev et al., 2021). The upper part is composed of lacustrine deposits (homogenized silty-clay gyttja). The middle part contains the limno-glacial deposits (varved clays). The lower part consists of glaciofluvial (sands and pebbles) and glacial (boulder loams) deposition. The organic gyttja is integral for the upper layers of bottom sediments in small lakes. Varved clays are distributed within the territory flooded by the waters of OIL in the Late Pleistocene (Fig.).

We collected the data on morphometric characteristics of 320 lakes and lithostratigraphy of 83 lakes. The literary, cadastral and archival sources, as well as expeditionary materials were used. The classification of lakes was carried out according to the genetic features of watershed relief. This approach was applied to Swedish lakes (Håkanson and Karlsson, 1984) located in similar environmental conditions of Fennoscandia. The ranges of variation and average values of morphometric characteristics were calculated, and structural features of bottom sediments were identified for each type of lakes.

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3. Results and discussion

Four types of lakes have been identified for the Lake Onego catchment area.

(I) Lakes of lacustrine plains (Vodlinskaya, Prionezhskaya and Shuiskaya, etc.) are characterized by a lower altitude, rounded shape and shallow depths. Relic lakes of the proglacial waterbody, and lagoon lakes represent them. The lower part of the bottom sediments is composed of varved clays (beginning of sedimentation about 16-15 cal ka BP). Silts (beginning of organogenic sedimentation about 10 cal ka BP) overlie the clays (Subetto, 2009).

(II) Lakes of till plains are characterized by a simple form and shallow depths. They are represented by glacial deposit-dammed basins (moraine-dammed lakes). The lower part of bottom sediments contains clays, loams and sandy loams overlain by silts (beginning of organogenic sedimentation about 9.5-10 cal ka BP).

(III) Lakes of marginal formations' uplands (Veshkelskaya, Vokhtozerskaya, Vodlozerskaya, etc.) are characterized by a higher altitude, small sizes and various depths. They are represented by glacial basins (moraine-dammed lakes, glaciokarst, etc.), and karst lakes in the southern part of the catchment area. The lower part of the bottom sediments is composed of clays, loams and sandy loams overlain by silts (beginning of organogenic sedimentation about 9.5-10.5 cal ka BP) (Subetto, 2009).

(IV) Lakes of denudation and tectonic relief are characterized by large size and elongated shape, high depths and cone-shaped basins. They are formed by tectonic lakes (depressions of synclinal and anticlinal folds, fault-line depressions, etc.). Two altitudinal levels of distribution of these lakes are distinguished: 35-75 m (lakes of the Zaonezhsky Peninsula) and 115-185 m (lakes of the West Karelian Upland). The first subtype marks the similarity in the structure of bottom sediments with type I, while the second subtype is similar to type II.

The organic gyttja features the recent lacustrine deposits of small lakes of the Lake Onego catchment. Most of the catchment area is located within the Fennoscandian Crystalline Shield (Fig.) and belongs to the region of Fe-Si-humus sedimentation, the Fe-humus sedimentation sub-region. The southern part is located within the Russian Sedimentary Plate and belongs to the region of organic sedimentation (Rossolimo, 1964). However, the studied lakes differ in the type of sedimentation. For example, the Fe-Si-humus type of sedimentation is predominant for small lakes of the Vokhtozero Uplandand (III) and Fe-humus-Si type for large lakes. The lakes of the Zaonezhsky Peninsula (I, II and IV) are expressed by a mixed type of sedimentation (Fe-Si-humus, Fe-humus-Si or humus-Fe-Si in accordance with the increasing mass fraction of the component in the sediment composition), but small lakes may have a monotype (humus, where organic matter makes up more than 80% of the sediment composition, or diatom sediments, where biogenic Si makes up more than 30% of the sediment composition) (Belkina and Kulik, 2019). Differences in sedimentation are determined by landscape features of watersheds (composition of rocks, relief, soils, vegetation, economic activity, etc.) and features of lakes (basin morphology, hydrological regime, chemical composition of water, biological characteristics).

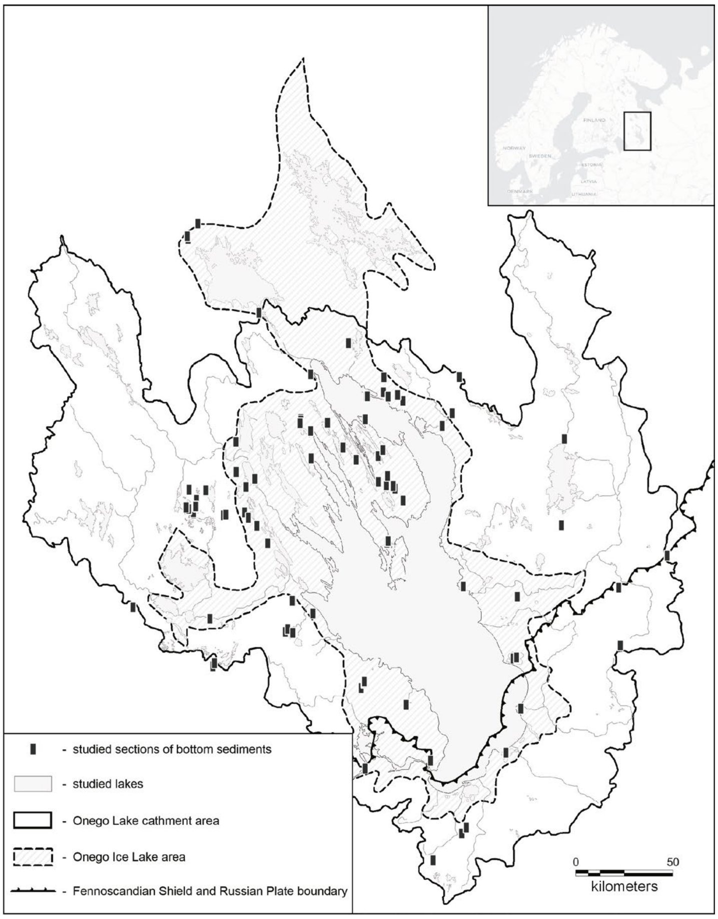

Fig. Lake Onego and its watershed.

4. Conclusions

For the Lake Onego catchment area, the four types of lakes have been identified, depending on the main types of relief: (I) lakes of lacustrine plains; (II) lakes of till plains; (III) lakes of marginal formations' uplands; (IV) lakes of denudation and tectonic relief. The structural features of lake basins and bottom sediments were identified for each type of lakes. We discover the morphogenetic features of lake basins and the landscape conditions of watersheds are local factors that affect the spatiotemporal transformation of lakes in the course of their development since the last deglaciation.

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Conflict of interest

The authors declare no conflict of interest.

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