Short communication

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Quaternary and geomorphological features of Lake Onego. Comparison with Lake Ladoga

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ABSTRACT. Lake Onego is a very important source of fresh water and traffic artery of Russian NW. In addition, it is a very significant source of paleogeographical and Quaternary geological information. Studies of geology, geomorphology, paleolimnology and ecology of Onego and Ladoga lakes are being conducted since 19th century by different institutes and research companies. At the modern stage of limnological research the most significant research centers are: Saint-Petersburg state university, Moscow state university, Limnological institute RAS, Northern Water problem institute RAS, PMGRE, VSEGEI, VNII Ocengeologia, and a lot of organizations with geology, ecology, limnology and hydrology specializations with Russian and foreign researchers. This article was written based on the results of field works conducted in 2014 - 2020. The article aimed to update the stratigraphy of Quaternary deposits of the Lake Onego bottom; describe bottom sediments and relief of Lake Onego; highlight stages of the Lake Onego bottom development according to geological and geomorphological features; compare Onego and Ladoga lakes' bottom sediments and relief.

Keywords: Quaternary geology, geomorphology, paleolimnology, bottom sediments, largest European lakes

1. Introduction

Lakes attract different researchers because it is significant source of information about modern nature conditions and paleoenvironment of region. Speaking of Russian North-West (NW), the biggest lakes of this region are Ladoga and Onego. In this work, maps of Quaternary sediments, geomorphological features and conditions of Ladoga and Onego lakes have been highlighted.

2. Materials and methods

Works carried out in Lake Onego included bottom sampling and geophysical research. Bottom sampling was carried out with gravitation corer (3 meters length) and vaan-ween bucket. Geophysical research included seismoacoustic profiling. The work resulted in more than 40 samples of bottom deposits and more than 800 kilometers of seismic profiles. After field works, dating and palinological and geochemical research were performed. Figure 1 shows sampling stations and seismic profiles.

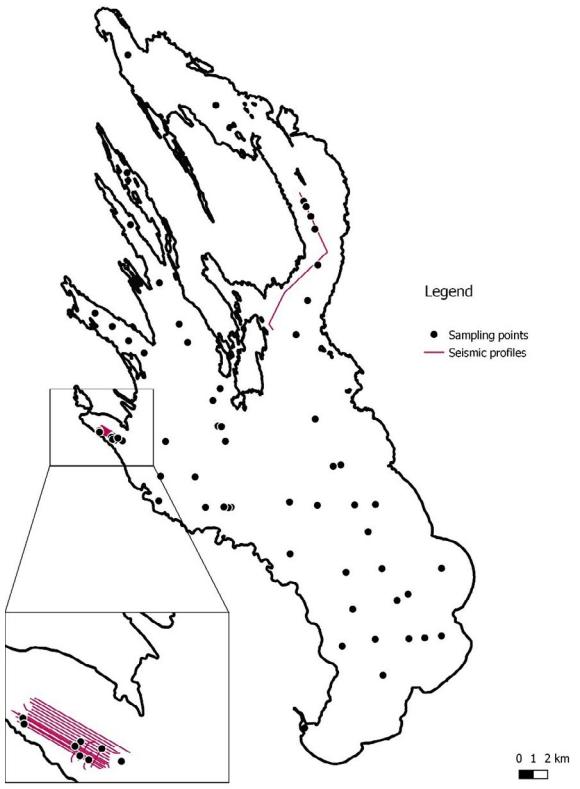

Fig.1. Map of fact material. Sampling points and seismic profiles.

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3. Results

There were the following types of deposits at the bottom of Lake Onego:

1. Moraines (gIIIos) laying at a depth of 4.85-5.44 meters blf. It consisted of gray-brown stiff loam with interlayers of sandy loam, inclusions of reddish sand and an admixture of pebbles. Towards the bottom, the density and the proportion of the sand-pebble fraction increased.
2. Fluvioglacials (fIIIos) forming eskers and accumulative fields, in some places they covered moraines (gIIIos). Consisted of brown-gray clayey sands, pebbles, sandy-clayey-silt miktites and gruss. Content of clay at the upper part could be the cause of reprecipitation of this deposits at the preglacial lake conditions.
3. Limnoglacial deposits (lgIIIos). Separates at three members ($lgIII_1os$, $lgIII_2os$, $lgIII_3os$), which correspond to three stages of preglacial lake conditions. The lower member ($lgIII_1os$) consists of rhythmic brown highly plastic clays, gray sands and sandy-clayey-silty mictites, there can be sandy bands up to 6 mm thick in this member. The middle member ($lgIII_2os$) consists of dark-gray sandy silts soft-hard plastic ribbon clays of gray-brown and brownish-gray color. At the upper part, visible influence of etching. The upper member ($lgIII_3os$) consists of gray, light brown, brown-gray microlayered clays, which turn into homogeneous fluid-plastic clays. It has sand linses, autigenic minerals (Strakhovenko et al., 2020) and pink clays, which are known as “pink horizon” (Demidov et al., 2004).
4. Modern lacustrine sediments (lnH) consisting of gray and greenish-gray fluid-plastic clayey silts and aleuropelites (lower part). The upper part is composed of greenish-gray gyttja and dark brown liquid clayey silt. Interlayers of sand, organic matter and authigenic minerals (Strakhovenko et al., 2020) are observed.

Also, at the bottom of Lake Onego pre-Quaternary bedrock exposures and undalluvium (lvIII-H) have been observed at the coastal part. Figure 2 shows the map of Quaternary sediments of Lake Onego.

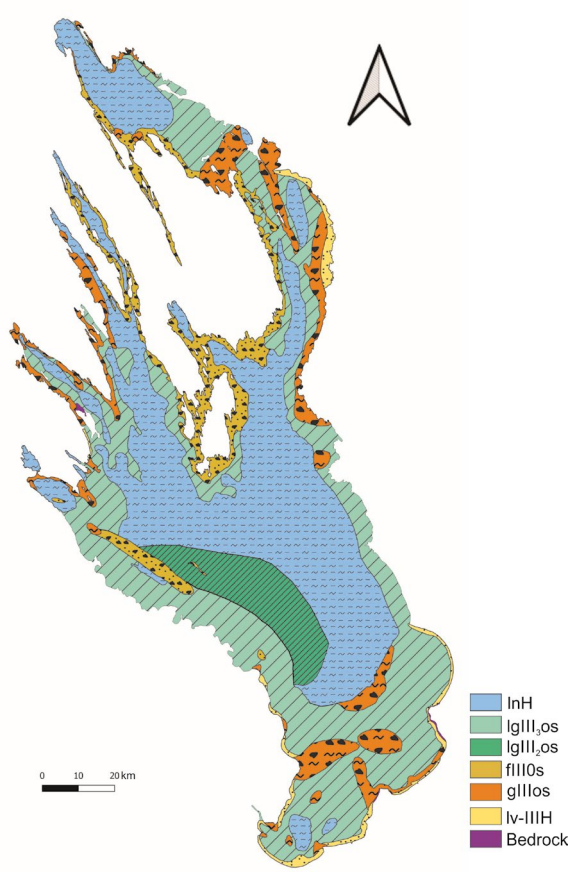

Fig.2. Map of Quaternary sediments of Lake Onego.

After analysis of data regarding Quaternary deposits and subbottom relief of Lake Onego, it became possible to describe geomorphological features of the lake. At the bottom of Lake Onego, six types of surfaces have been observed (Beliaev et al., 2020). Here is the description of these types:

1. Intensively dissected ridge and fiardo-skerry plains on a crystalline substrate with the modern geodynamic processes. Developed at the northern part of the lake, have highly dissection, many south-eastern oriented ridges and little basins of sedimentation.
2. Ridge-wavy plains on the prepared crystalline substrate with glacial accumulative elevations. Developed at northern, north-western and southern parts of the lake, near the coast. Middle-dissected, have ridges of glacial genesis.
3. Hilly-ridged glacial and glacier-lacustrine plains on a moraine substrate (zones of marginal formations). Available in the northern, northeastern coastal and southern parts of the lake. Middle-dissected, with glacial and fluvioglacial ridges, height up to 20 meters.
4. Flattened lacustrine nepheloid plains. They occupy the middle part of the lake, and deepest parts of the bays. Characterized by the lowest dissection of surface and the maximum thickness of lacustrine deposits.
5. Subhorizontal flattened glacier-lake plains. Developed at the central and southern parts of the lake. Depths - from 10 to 70 meters. The relief is poorly dissected. At their core, they are accumulative fields formed by accumulation, characteristic of glacial reservoirs. Terraced surfaces are observed in the coastal part.
6. Undaluvial, slightly sloping plains. They were identified in the coastal zone of the South Onego Bay and in the east of the Zaonezhsky Bay. Depths less than 10 meters, there is a slope towards the deep part of the lake. Their genesis corresponds to hydrodynamic (wave) activity.

All of the types of underwater surfaces are depicted at geomorphological map (Fig. 3).

4. Discussion

Comparison of Ladoga and Onego lakes. Quatenary sediments of Lake Onego represent glacio-sedimentary cycle with the following sediments: moraines-fluvioglacials-limnoglacials-lacustrine sediments. Each type of the sediments corresponds to stage of development of the lake during Neopleistocene and Holocene. The same sequence of sediments we have in Lake Ladoga.

If we talk about geomorphological features, we have to say, that at the bottom of Lake Onego there were observed only six types of surface, but at the bottom of Ladoga – nine types. In general, underwater surfaces of Ladoga and Onego lakes are more dissected at the northern part, and less dissected in southern. But surface of the Lake Ladoga bottom is less isometric in terms of longitudinal profile. In Lake Ladoga, deeper part is the north of the lake, but in case of Lake Onego, central part is deeper. The biggest thickness of Quaternary deposits for Lake Ladoga is typical in the northern part, and for Onego, in the northern, also in the central part. However, in both lakes, the smallest thickness of lake deposits is typical for the southern part.

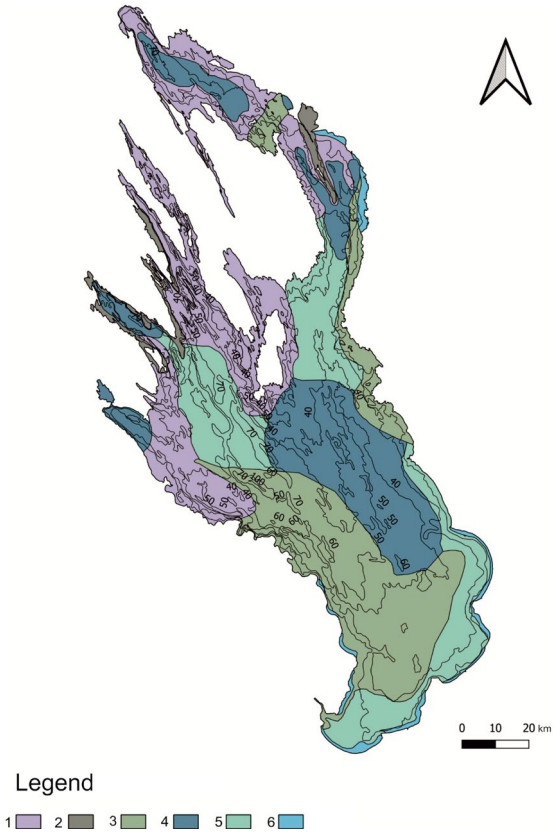

Fig.3. Geomorphological map of Lake Onego.

5. Conclusions

Ladoga and Onego lakes have common features in Quaternary sediments and its distribution at the subbotom surface. The differences are in geomorphological features, which corresponds to some paleogeography development conditions and structure of crystalline basement. In addition, modern hydrodynamic features influence sedimentation processes and distribution of the sediments.

Acnowledgments

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Conflict of interest

The authors declare no conflict of interest.

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