# Distribution of Surface Sediments at the Bottom of Lake Ladoga

Vladimir Anokhin, Dina Dudakova, Aleksey Aksenov, Mikhail Dudakov, and Anna Revunova

**Abstract**

Lake Ladoga is the largest source of fresh water in Europe, on which the health and lives of millions of people depend. Bottom sediments affect the water quality in the lake. Therefore, it is necessary to study them. Researchers from the Institute of Limnology of RAS are looking at the distribution of surface sediments at the bottom of Lake Ladoga using new methods. Based on the research results, a new map of the distribution of bottom sediments has been compiled, which can serve as a qualitative basis for monitoring the ecological situation in the lake.

**Keywords**

Lake • Sediments • Bottom relief • Distribution • Bottom sampling

## 1 Introduction

Lake Ladoga is the largest lake in Europe in terms of area and a source of fresh water for the metropolis of St. Petersburg and the adjacent regions. Therefore, studying the distribution of the lake's bottom sediments is an important and urgent task. During the study of the lithology of the base of Lake Ladoga, a significant amount of knowledge has been accumulated, and several works have been published, for example (Naumenko, 2020; Rumyantsev et al., 2015; Semenovich, 1966; State Geological Map of the Russian Federation Scale, 2015).

In 2019–21, employees of the Institute of limnology RAS (ILRAS) carried out a study of the bottom sediments of Lake Ladoga. The results of these works form the basis of the proposed publication.

## 2 Methods

The research methodology includes bottom sampling, echo sounding, an underwater photo-video survey of the tail, particle size analysis, and mapping bottom sediments based on digital bottom topography models.

Bottom sampling is the primary source of information in this study. It was carried out using a Lauri-Niemiste ground pipe on fine-grained sediments and an Ekman-Burge bottom grab on sandy sediments. Of the entire core of the tube, the top 10 cm of sediment was taken into account for mapping. Sampling was carried out over a subregular network of stations, more or less evenly distributed throughout the entire water area (191 stations).

The underwater survey was carried out using the "Limnoscout" underwater vehicle, designed and assembled at ILRAS (Anokhin & Dudakova, 2020), at a significant part of sampling stations. In addition, the bottom was a photo-video profiled in several local coastal areas.

Echo-sounding was applied at each station pointwise and in combination with photo-video profiling in coastal areas.

For cartographic constructions, a digital model of the relief of the bottom of Lake Ladoga was used, compiled by Mikhail Naumenko at ILRAS (Naumenko, 2020).

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## 3 Results

Based on the results obtained, the authors created a map of the distribution of bottom sediments in Lake Ladoga (Fig. 1). The map shows that according to the distribution of deposits, the bottom of the lake, in the first approximation, can be divided into two zones—northern and southern.

The northern zone is dominated by olitic silts, which are replaced by other sediments at the bottom elevations. In the southern site, mainly sandy sediments are widespread, decreasing their size from the coast to the center of the water area from coarse-grained sands to aleuro-sands and sandy silts.

There is general preservation in the northern part of the usual zoning of bottom sediments in large reservoirs with bedrock banks with increasing depth (bedrocks—coarse-clastic—medium-clastic—fine-clastic—fine-clastic). There are also many deviations from this sequence. In particular, the filling of shallow-water zones in the fields of the northern coast of the lake with pelites is noticeable, where these sediments come almost to the very beach, composed of bedrocks, to a depth of several meters.

On the basins' sides are locally manifested olitic sediments, band-like, and band clays. According to many features, we refer to one group of sediments, well-known as deposits of the Baltic Glacial Lake. This ancient glacial reservoir occupied a vast area at the beginning of the Holocene, which included, in addition to the present-day Lake Ladoga, a large part of the Baltic Sea. Moraine (glacial) deposits most likely underlie band clays.

Glacial boulder-rubble deposits are distributed along the entire bottom in local glacial forms and in strips along the coast. Found that large glacial ridges have a bedrock base.

In the southern part of the lake, fragments of clay were found in bottom sediments, similar to the "blue" clay of the

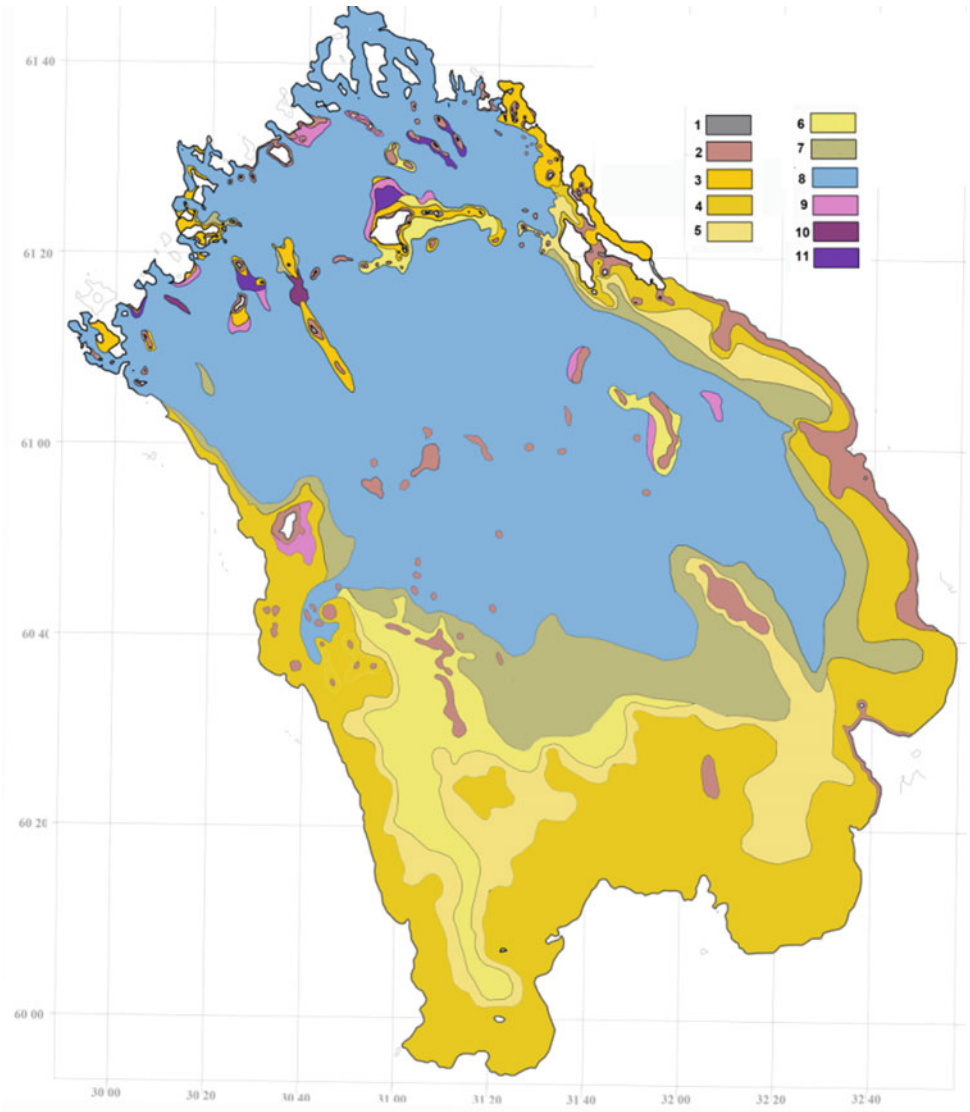


**Fig. 1** Map of the distribution of surface sediments of the bottom of Lake Ladoga: 1—bedrocks and their large fragments, 2—boulder-block, pebble-gravelly deposits, 3—undivided sands, 4—coarse-grained sands, 5—medium-fine-grained sands, 6—silt-sands, 7—sandy silts, 8—pelitic silts, 9—silty pelites, 10—clays, 11—band-like, band clays

Cambrian age, which partially composes the southern shores of Lake Ladoga. Perhaps, this will make it possible to clarify the distribution of Cambrian clays at the bottom.

## 4 Discussion

Currently, two main cartographic products contain information on the distribution of bottom sediments at the bottom of Lake Ladoga. This is the scheme of the distribution of bottom sediments of Lake Ladoga, Semenovich (1966) and the scheme of bottom sediments from the set of the State Geological Map of the Russian Federation (2015).

Semenovich's scheme is the most detailed and substantiated factual material, and it has faithfully served researchers studying Lake Ladoga for over 50 years. However, the methods of the twentieth century's late 50 s were used when constructing it. In particular, the geographic referencing of the stations had an accuracy of 1–2 km. But much more serious is that there was no high-quality detailed bathymetric base at that time. And the bottom topography is a decisive factor in the distribution of bottom sediments. Thus, Semenovich's constructions are essentially outdated by now.

A much newer lithological scheme from the set of the State Geological Map has a rather small scale of 1:1,000,000. Therefore, it is impossible to see the geomorphological and lithological details of the bottom structure on it.

Our research was carried out using a GPS satellite binding, giving deviations in a matter of meters. When constructing our map, we used the most detailed digital elevation model available for Lake Ladoga. Of course, the authors made full use of all the constructions of their predecessors, paying particular attention to the two mentioned sources.

The authors are aware that all the above conclusions and constructions are debatable. Nevertheless, there is confidence that ongoing research will bring us closer to an accurate picture of the distribution of bottom sediments of Lake Ladoga.

## 5 Conclusions

The following features characterize the distribution of surface sediments at the bottom of Lake Ladoga. (1) In the northern part of the lake, pelitic silts dominate at the bottom, filling all depressions, the sides of which are composed, apparently, sediments of the Baltic glacial lake. (2) Band clays are probably underlain by glacial deposits, which, in turn, are capped by bedrocks. (3) In the southern part of the lake, mainly sandy sediments are widespread, the distribution of which obeys the usual zoning of decreasing the size of the constituent particles from the coast to the center of the water area, from coarse-grained sands to silty sands and sandy silts. (4) The discovery of fragments of (maybe) Cambrian clay in sediments of the southern part of Ladoga may make it possible to clarify the boundary of the distribution of bedrock clays.

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