

Lithoseismostratigraphy and features of the paleogeographic development of Lake Onega and the White Sea in the Late Pleistocene and Holocene

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ABSTRACT. Analysis of the latest seismic acoustic data, geological work at the key Polygon "Petrozvodsk Bay" in Lake Onega and analysis of literature data, including the results of our own recent work at Lake Ladoga, are given in our article. Seismostratigraphic and lithostratigraphic characteristics of Quaternary deposits at the key Polygon are given. Drilling from the ice in the Petrozavodsk Bay carried out in March 2019 made it possible to characterize the entire Quaternary sediment sequence. The performed tomographic studies of the selected sediment corers made it possible to more fully characterize the sedimentation conditions in Lake Onega in the post-glacial time. The presence of glacial deposits has been proven in the lowermost part of the recovered Quaternary section. For the first time, the lithological characteristics of fluvio-glacial deposits are given. Palynological studies made it possible to show that, despite the similarity of lithofacies and their interlayering in the section, the time of the retreating of last glaciers from Lake Ladoga and Lake Onega depressions was different.

Keywords: Lake Ladoga, Lake Onega, bottom sediments, seismoacoustic profiling, seismostratigraphy, lithostratigraphy, tomography of sediments, Late Pleistocene, Holocene, till, fluvio-glacial deposits

1. Introduction

One of the controversial issues in the Late Quaternary paleogeography of the Northwest of the Russian Federation is the problem of the formation of the internal seas (the Baltic Sea and the White Sea) and the largest European lakes (Lake Ladoga and Lake Onega). At the same time, if the Quaternary geology of the Baltic and White Seas is sufficiently well studied (Geology and Geomorphology..., 1991; Nevessky et al., 1977; Rybalko et al., 2018b; Spiridonov et al., 2007), then this cannot be said about the lakes and, first of all, about Lake Onega. Stratigraphic data and paleogeographic conclusions are mostly based on the data of studying short (up to 1 m) sediment corers, as well as the results of drilling of shallow lakes around Lake Onega. Practically, only in Russian-Finnish

research in 2005 made it possible to obtain long sediment corers, on which most of the paleogeographic reconstructions are based (Saarnisto et al., 1995).

In this report, we would like to focus on the latest data about litho- and seismostratigraphy of bottom sediments of the Petrozavodsk Bay, Lake Onega, obtained during the several field campaigns in 2016-2019 organized by the Northern Water Problems Institute KarRS RAS, the Center for Marine Research of Moscow State University, the Institute of Earth Sciences of St. Petersburg State University and Herzen State Pedagogical University.

2. Materials and methods

It has been conducting seismic-acoustic studies in the both Lake Ladoga and Lake Onega since 2014

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(Rybalko et al., 2018a) using multi-channel high-resolution equipment with the Sparker and Bummer sources. In 2016, in the Petrozavodsk Bay of Lake Onega, complex geological and geophysical studies were carried out for the lithostratigraphic division of the supraglacial sediments. Geophysical work preceded sampling. Their task was to obtain a general seismostratigraphic section of loose deposits and to select places where sediments of different ages approached the bottom surface. The geophysical complex included: ultra-high-resolution seismic prospecting (SSVR) with a boomer source and a 16-channel analogue seismic streamer, ultra-high resolution seismic exploration (UHRS) with a parametric profiler SES-2000 Light, side-scan sonar (GLBO) with a Klein450. This complex allows for detailed studies of the bottom and bottom boundaries, providing a depth of up to 50-100 m (Aleshin et al., 2019).

According to the interpretation of seismoacoustic profiling data, 8 sampling points were selected in the Petrozavodsk Bay. Geological sampling was carried out by gravity corers of 3 m long and 127 mm in diameter. The total weight of gravity corers was of 300 kg. The field works were carried out from the R/V "Professor Zenkovich". In subsequent years, geological sampling and seismoacoustic profiling was extended to the open part of Lake Onega (2016-2019). The drilling of bottom sediments of the Petrozavodsk Bay was carried out from ice cover in the March 2019. It was carried out using a piston coring system for sampling bottom sediment manufactured by UWITEC (Austria). It allows as to take bottom sediment cores up to 20-25 m long, with a water depth of up to 140 m (Rybalko et al., 2018a).

3. Results and Discussion

The first lithostratigraphic scheme of bottom sediments from the Petrozavodsk Bay, Lake Onega, was drawn up based on the data of geological sampling. At the base of the recovered sediment sequence, there are limno-glacial (varved) clays. Glacial (till) and fluvioglacial deposits (1) lie at the base of the section of Quaternary deposits, overlapping Proterozoic crystalline rocks. They are composed of dense clayey sands with pebbles and gravel of crystalline rocks and unsorted sands. They are overlain by a layer (2) of varved clays: thick-bedded at the bottom, thin-bedded to monotonic at the top of section. These are deposits of preglacial Onega Ice Lake of various stages of its development. Uppermost part of sediment section (3), a complexly constructed stratum of Holocene lacustrine sediments occurs. At the base there is a member of thin gray aleurolites (soft clays) of fluid-plastic consistency (3a). Clays are homogeneous, sometimes indistinct accumulation of manganese hydroxides and pyrolusite is noted. The uppermost part of section (3b) is represented by a layer of typical lacustrine muds (clay gytja). Palynological studies and radiocarbon dating were carried out in the sediment columns. The determination of the absolute age was carried out on the basis of organic matter. Two dates within the 3rd part of sediment sequence, uppermost stratum, were

obtained (~1340 and ~2510 cal. yrs BP), which clearly fit into the interval of the Upper Holocene. According to biostratigraphic studies, the most ancient sediments were classified as Allerød.

The drilling data confirmed the presence of this type of sediment stratigraphy and allowed it to be extended from below. Proximal, already substantially sandy, varved clays were uncovered, which are underlain by dense sandy clays and clayey sands containing fragments of pebble and small boulders. These deposits were, by analogy with the inland seas and Lake Ladoga, referred to till the Last Glaciation. At the same time, in one of the wells at the base of the section, a stratum of unsorted sands was uncovered, which we referred to as fluvioglacial (Rybalko et al., 2018a).

The performed palynological analyzes (on sediment sequences from small lakes around Lake Onega and from the Petrozavodsk Bay) allow us to attribute the stratum of gray clays to the Late Pleistocene, although on Lake Ladoga similar clays belong to the Lower Holocene (Subetto, 2009). Thus, preliminary data suggest that the lacustrine stage of sedimentation in Lake Onega began later than in Ladoga Lake. The same can be said about the beginning of the marine stage of sedimentation in the White Sea (Rybalko et al., 2018b). Thus, the hypsometric position of the periglacial basins significantly affects the time frame of their existence. The report also provides information on the mineral and geochemical composition of the identified units of the Quaternary deposits.

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