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Bottom sediments of the Eastern part of the Onega Peninsula Lakes in the context of the White Sea relative level changes

Kublitskiy Yu.A.[1]*, Repkina T.Yu.[1,2], Leontiev P.A.[1], Gurinov A.L.[3], Serdyukov A.G.[1], Lugovoy N.N.[1,4]

[1] *Herzen State Pedagogical University of Russia, 48 Nab. Moyki, St. Petersburg, 191186, Russia*
[2] *Institute of Geography RAS, 29 Staromonetnyy lane, Moscow, 119017, Russia*
[3] *Department of Landscape Design and Sustainable Ecosystems, Agrarian-Technological Institute, Peoples Friendship University of Russia, 6 Miklukho-Maklaya Str., Moscow, 117198, Russia*
[4] *Faculty of Geography of Lomonosov Moscow State University, 1 Leninskie Gory, Moscow, 119991, Russia*

ABSTRACT. Geomorphological, ground penetration radar profiling and paleolimnological investigations were carried out in the Kobyl`e (11 m asl), Chevakino (7 m asl), and Lopshen`gskoye (1 m asl) Lakes. Based on the lithology data, we obtain the relative sea-level (RSL) changes in the northern part of Gulf of Dvina (White Sea, Arctic Ocean) during the Holocene. The levels of two transgressions (Late Glacial and Tapes) and one Early Holocene regression are identified. According to the lithology composition of bottom sediments, investigated lakes has a longer transitional stage, then lakes in 22 km to the south.

Keywords: sea level change, Holocene, paleolimnology, Tapes, White Sea, Letnij coast, isolated basins, lithology

1. Introduction

Changes in the relative level of water basins on the periphery of Scandinavian Ice Sheet (SIS) since the Last Glacial Maximum (LGM) were caused by glacioisostatic adjustment (GIA) due to changes in the load of the ice mass, vertical tectonic movements, glacioeustatic and eustatic fluctuations in the volume of water in the sea basin (Mitrovica et al., 2011), and changes in wave activity (e.g., Møller et al., 2002). A complex combination of global, regional, and local phenomena determines the differences in RSL dynamics along the shoreline of reservoirs. The aim of this study is collect and obtain new paleolimnological and lithological data in context of RSL changes and compare these data with published results. It is important for constraining regional paleogeographic reconstructions, understanding the patterns of development of coasts on the periphery of Late Pleistocene ice sheets, and verifying models of RSL dynamics.

2. Materials and methods

Study area. The studied lakes are located in the northern part of the Onega Peninsula of the White Sea. On the landward side, the lake cores adjoin the marginal structures of the Neva degradation stage of the last glaciation (Zorenko et al., 2000), and on the seaward side, they are bounded by disconnected, low (up to 20-30 m) moraine ridges and hills. At heights of 10-15 m, gently sloping abrasion and abrasion-accumulative terraces developed on their apical surfaces and slopes, the formation of which may be compared to the Late Glacial transgression (~13-11.5 ka BP) (Kolka and Korsakova, 2017). According to (Zorenko et al., 2000), the deposits of this transgression-sands, sandy loam, and clays-can be traced to ~20 m a.s.l. However, we did not find any morphological evidence of the impact of coastal processes on the glacial topography at elevations higher than 15 m.

The basins of the lakes Kobylie and Chevakino are located in a depression of complex configuration, have irregular plan outlines and are connected to each other by a dry channel. With the position of the relative sea level at the marks of 11 m and more, they were probably parts of a single system of straits that connected the estuary of the Malaya Syarta River to the Sea. At present, Lake Chevakino is undrained. The runoff from Lake Kobylie is carried out by the Malaya Syarta River, flowing in the south and flowing out in the north of the basin.

The Lopshenga Lake basing formed in the mouth part of the Lopshenga estuary and located in an elongated depression.

*Corresponding author.
E-mail address: uriy_87@mail.ru (Yu.A. Kublitskiy)

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Methods. Field investigations included DGPS and surveys, geomorphological and ground penetration radar profiling and coring of the lake sediments.

Coring was carried out from the ice using a Russian peat corer. It was accompanied by lithological and stratigraphic description according to the methodology (Subetto, 2009) and core sampling for analytical studies and radiocarbon dating. GPR studies were carried out using Zond-12e ground penetrating radar and 300 MHz antenna (average depth - up to 10 m, resolution - first tens of centimeters). The first results of core analyses were obtained.

3. Results and discussion

According to the lithological and stratigraphic description of the cores, five horizons are distinguished in the section of bottom sediments of the Kobyl`e Lake (320-967 cm from the water surface). On the dense sandy silt-gray loams with macrofossils (1) lies peat with wood fragments (11 cm) (2); its accumulation by analogy with the same sediments from Lake Murakanskoye (Kublitskiy et al., 2022), can be tentatively correlated with the regression of the Early Holocene. This layer is overlying by peaty silt and replaced up the section by stratified and thinly stratified silt of gray-brown to grayish-olive color (168 cm) (3). Higher up, interbedded gray-bear, brown, and light gray sandy silt occur (145 cm) (4). The lower half of the sequence contains peat layers and wood detritus. The composition of the sediments indicates variable conditions of their accumulation, which could possibly be related to the proximity to the seashore during the Tapes transgression. The upper horizon of the section is represented by lake sediments - homogeneous brown gyttja, sometimes enriched in silt] (330 cm) (5).

The bottom sediments of Lake Chevakino (280-920 cm from the water surface) have a similar overlaying character. However, the composition of horizons 3 and 4 is not identical to similar horizons from Lake Kobyl'e. Above the peat (4 cm), there are gray and dark gray sandy and clayey silt, homogeneous or with periodic stratification, containing microfossils of plants and, possibly, hydrotroillite (201 cm) (3). The silt of the "motley" horizon (180 cm) (4) contain more sand and fewer organic inclusions. Probably, this layer have accumulated at the end of the Tapes transgression, at the stage of separation of the enclosed bay from the sea.

The bottom sediments of Lake Lopshenga (180-938 cm from the water surface) have a more complicated structure. In the lower part of the section, dense sandy loams with reddish and black admixes (1) were uncovered (20 cm), probably it is rewashed glacial sediments. Above them, loamy sands with plant fragments (32 cm) (2), overlain by silt (11-20 cm) (3) and then by sandy silt with detritus and whole clam shells (101 cm) (4), with an erosional contact. The grain-size composition of the sands indicates a gradual increase and then a decrease in hydrodynamic activity. M.A. Lavrova (Lavrova, 1931) attributes similar deposits described in the basement of 4-7 m high terraces near the village of Yarenga and in some other areas of the Onega Peninsula to the final stages of the Late Holocene transgression. In the delta of the Northern Dvina River, sands with marine mollusk fauna are underlain by Early Holocene peat (Koshechkin, 1979). The transitional horizon (5) has a considerable thickness (436 cm) and is represented by interstratification of gray, black, and dark olive sandy silt with plant remains and isolated wood fragments. The grain-size composition of the upper horizons of the section consisting of sandy-silty gyttja (52 cm) (6) and sandy silt (42 cm) (7) suggests fluctuations in hydrodynamic activity during the final stages of sediment accumulation.

Comparing the results with previous studies conducted 22 km south of the site (Kublitskiy et al., 2022), we can state a difference in the lithological structure of the bottom sediment strata. The lakes considered in this paper have a thick horizon of stratified sandy silt, while in the lakes located to the south, this horizon is thin. This peculiarity may indicate more prolonged transitional conditions in the studied lakes.

4. Conclusions

During the maximum Late Glacial transgression (~13-11.5 ka BP) (Kolka and Korsakova, 2017), the relative sea level was apparently ~15 m higher than today. Terraces were formed on the slopes of the moraine ridges and estuaries existed in the estuaries of the Lopshenga, Bol`shaya and Malaya Syarta. During the Early Holocene regression (~11.5-9.8 ka BP) (Kolka and Korsakova, 2017), the basins of Lakes Kobyl`e and Chevakino were drained. No traces of regression were found at the mouth of the Lopshenga River. Apparently, the estuary of the river shifted after the receding sea, and its channel cut into the previously accumulated sediments, destroying them. In the Middle Holocene, during the Tapes transgression (~8.2-5.8 ka BP) (Repkina et al., 2020), the relative sea level reached ~9 m and then gradually declined. Terraces with heights of 7-9 and 5-6 m above the modern sea level were formed. In the Late Holocene, the relative sea level gradually decreased, and terraces at 2.5-3 m and then the modern one (up to 1 m) were formed.

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Conflict of interest

The authors declare no conflict of interest.

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