Short communication

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Relative sea-level variations indicated by micropaleontological data from small lake bottom sediments (Kandalaksha Bay, NW Russia)

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ABSTRACT. The results of the micro-paleontological study of bottom sediments from a small lake on the Kandalaksha Bay shore of the White Sea are reported. Three stages in the evolution of the lake basin: marine, transitional and lacustrine were recognized. The characteristics of their diatom complexes and palynological spectra were revealed. Marine-facies sediments were shown to be dominated by poly- and mesohalobes, their share in the transition facies is twice as small, and freshwater diatom complexes contain up to 10% halophiles. Facies were shown to be reliably identified, using the pollen and spores of distinctive species indicative of certain ecological conditions. Non-pollen palynomorphs (algae Pediastrum, Botryococcus and sponge spicules) can be used for identifying various facies. These data will be used later to more reliably and objectively reconstruct variations in relative sea level and the sea shoreline migration in the Holocene. A decrease in sea level was established at the turn of 7200 cal. years and the isolation of the lake from the sea occurred about 6700 cal. years ago.

Keywords: Holocene, bottom sediments, pollen analysis, diatom analysis, White Sea

1. Introduction

Shoreline migration results from the interaction of many factors: the glacioisostatic uplifting of the earth crust, eustatic variations in ocean level and tectonic movements proper in the Kandalaksha Graben area (Kolka et al., 2015). The study of White Sea shoreline migration is essential for approaching various problems in the paleogeographic reconstruction of the environment on the sea shore. A number of works have been devoted to changing the position of the coastline in this area (Kolka et al., 2015; Korsakova et al., 2016).

Bottom sediments from five lakes located at an altitude of 4 to 37 m above sea level (a.s.l.) were studied using micropaleontological methods. The isolation from the White Sea paleobasin and evolution of one of them are discussed below. Obvious indicators of the position of the coastline of the sea during the isolation of lake basins are complexes of diatoms. The article demonstrates that pollen, spores of certain taxa and non-pollen palynomorphs can also be used in the study of basin isolation.

2. Materials and methods

A nameless lake (37 m a.s.l.) selected as an object for this investigation is located on the Karelia coast of Kandalaksha Bay of the White Sea near at the mouth of the Keret River. For defining stages in sedimentation we investigated bottom sediments by diatom and palynological analyses. Methods for processing and studying samples by diatom analysis are described in (Shelekhova et al., 2021). Samples for palynological analysis were treated using generally accepted procedures (Pyl'tsevoy analiz, 1950). A study of non-pollen palynomorphs (Botryococcus and Pediastrum) was also carried out.

3. Results and discussion

It has been shown that the bottom sediment sequences are represented by three facies: marine, marine- to lacustrine transition and freshwater.

Upon silty clay sedimentation with mollusk shell inclusions in the thickest **marine facies**, exposed by drilling, the diatom complex consists of polyhalobes (95-60%), mesohalobes (10-20%) and halophiles (4-10-15%). The percentage of polyhalobes in the upper portion of marine sediments decreases to 60%, while meso- and halophiles increase to 30%. Indifferent freshwater forms make up about 10% of the complex also comprises. Structurally, the marine facies falls into two subfacies. The first one, dominated by the

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planktonic polyhalobic species (90-95%) of the genera *Hyalodiscus*, *Thalassiosira* and *Chaetoceros*, as well as the polyhalobic bottom forms *Trachyneis aspera* etc., formed in a deeper-water basin. During a second marine subfacies, when silt accumulated, the percentage of planktonic *Hyalodiscus* sp. declined to 5-25%. Centric "deep-water" marine forms were succeeded by the littoral *Paralia sulcata* and littoral pennate forms of the genera *Grammatophora* (40%), *Trachyneis* et al., as well as the species of the genus *Tribrionella* (about 10%). Consequently, the sea level also decreased at that time.

Marine-facies sediments were shown to contain the pollen of halophytic plants from the maritime saline White Sea ecotopes, such as *Plantago maritima*, *Atriplex nudicaulis*. There is pollen, according to its morphological features, belonging to the type Aster. But in terms of ecology and geographical distribution, *Tripolium vulgare* is the most compatible.The abundance of sponge (Porifera) spicules suggests sedimentation in a marine environment, because most sponge species prefer a marine habitat. It should be noted that they are less abundant in the upper part of the facies, while halophytic plant pollen occurs more often.

In the **transition** layer 2 cm thick (gyttja with silt impurity), the proportion of poly- mesohalobes and halophiles decreases by half, not exceeding 50% in total. All of the above species make up from 2 to 10%, many are few in number. The other part of the complex consists of indifferent freshwater species from the genera *Aulacoseira* sp., *Cyclotella* sp., *Staurosira* sp., *Tabellaria* sp. and others. During the formation of this facies, the reservoir underwent a transition from a sea bay to an isolated lake with sea water in the bottom layer, when sea water entered it by tides. Since the marine environment has been replaced by freshwater, the continuous curve of pollen from halophytic plants has dropped out of the palynological spectra and wedged out. There are few microfossils of plants from freshwater reservoirs (*Nymphaea, Nuphar, Sparganium*) and remains of *Pediastrum* algae. Apparently, the plants that produced this pollen grew in the shallow zone of the already desalinated bay. The increase in Cyperaceae pollen is associated with the emergence of waterless saline habitats. They were inhabited by sedge, many species of which are halophytic. According to another scenario, the shallow zones of the isolating reservoir could be inhabited by glycophytes of this family. Sponge spicules were not found in transitional facies. The thinness of the deposits, indicating a transition from marine to freshwater conditions of sedimentation, indicates a rapid regression of the sea and isolation of the lake. Radiocarbon dates obtained from the gyttja layer with an admixture of silt (Tolstobrov et al., 2021) indicate a sea level decrease of 7200 cal. y. a. and the lake sharply separated from the sea 6700 cal. y.a.

The **freshwater** facies is represented by sapropels (gyttja) in which the diatom complex consists of 80-90% freshwater species from the genera *Aulacoseira* sp., *Cyclotella* sp., *Staurosira* sp., *Tabellaria* sp., *Anomoeoneis* sp., *Frustulia* sp., an insignificant amount (up to 2 %) species of the genera *Epithemia*, *Pinnularia*, *Navicula*, *Eunotia*, *Gomphonema*; single poly-, mesohalobes and halophiles. Up the section, the proportion of halophobes increases, and the reservoir becomes "acidified". The sediments contain the pollen of plants growing in freshwater bodies (*Myriophyllum alterniflorum, Nuphar luteum, Nymphaea alba*, *Typha angustifolia, Sparganium*), *Isoëtes* spores and the algae *Pediastrum* and *Botryococcus*. The amount and diversity of pollen and spores are not great. It should be noted that lakes in North Karelia typically display the poor species composition of higher aquatic vegetation.

4. Conclusions

Diatom and spore-and-pollen analysis has revealed sediments of various sedimentation facies. A marine facies is indicated by diatoms dominated by marine poly- and mesohalobes, the pollen of halophytes from the maritime salinized White Sea ecotopes and sponge spicules; in the transition zone, the percentage of marine diatom species decreases by 50%, halophyte pollen disappears from spectra, and sediments from the separated lake contain the pollen, spores and algae of freshwater bodies. The results of the combined study of lake bottom sediments have shown that about 7200 cal. y. a. it was a fairly deep sea bay. 7200-6700 cal. y. a., the sea level declined abruptly and 6700 cal. y. a. the bay separated completely from the sea.

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Conflict of interest

The authors declare no conflict of interest.

References

Kolka V.V., Korsakova O.P., Shelekhova T.S. et al. 2015. Reconstruction of the relative level of the White Sea during the Lateglacial-Holocene according to lithological, diatom analyses and radiocarbon dating of small lakes bottom sediments in the area of the Chupa settlement (North Karelia, Russia). Vestnik MGTU im. N.E. Baumana. Seriya «Yestestvennyye nauki» [Herald of the Bauman Moscow State Technical University. Series "Natural Sciences"] 18(2): 255-268. (in Russian)

Korsakova O.P., Kolka V.V., Tolstobrova A.N. et al. 2016. Lithology and Late Postglacial stratigraphy of bottom sediments in isolated basins of the White Sea coast exemplified by a small lake in the Chupa settlement area (Northern Karelia). Stratigraphy and Geological Correlation 24(3): 294-312. DOI: 10.1134/S0869593816030035

Pyl'tsevoy analiz [Pollen Analysis]. 1950. In: Ed. Pokrovskaya I.M. (Ed.). Moscow: Gosgeolizdat. (in Russian)

Shelekhova T.S., Lobanova N.V., Lavrova N.B. et al. 2021. Paleogeographic conditions of human habitation on the Karelian coast of the White Sea in the Late-Holocene (Chupa Town, Karelia, Russia). The Holocene. DOI: 10.1177/09596836211041733

Tolstobrov D.S., Vashkov A.A., Kolka V.V. et al. 2021. Preliminary data about sea level change near the Keret village, North Karelia. Trudy Fersmanovskoj nauchnoj sessii GI KNC RAN [Proceedings of the Fersman Scientific Session of the GI KSC RAS] 18: 368-371. DOI: 10.31241/FNS.2021.18.069 (in Russian)