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On the marine limit at the Kandalaksha Coast, the White Sea: new data from Lake Kanozero, a huge isolation basin in the middle course of the River Umba

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ABSTRACT. The study revealed the evidence for the marine waters penetration into the basin of Lake Kanozero (SW part of the Kola Peninsula) in the Late Glacial. While previous studies found no signal of marine transgression above ca. 41 m a.s.l., our results suggest that the local marine limit exceeded ca. 53 m a.s.l., and the sea ingressed as far inland as ca. 50 km from the present White Sea coast.

Keywords: relative sea level changes, diatoms, isolation basins, Late Glacial marine transgression

1. Introduction

Lake Kanozero, located in the SW part of the Kola Peninsula (Fig. 1A) is famous by the ancient stone-carvings abundant on its islands. The evidence of the early human presence on its shores has raised interest to the lake's paleoenvironments. The multy-proxi study of the upper part of the sediment sequence from Lake Kanozero covering the end of the Late Glacial and the Holocene has been performed and published elsewhere (Sapelko et al., 2022). The lowermost sediments that archive the record of the earliest stage of the lake's evolution, however, remained beyond the scope of that publication, and are in focus of the present study. Here we discuss the results of the diatom analysis of the lowermost part of the sediment sequence aimed at reconstructing the initial stage of the development of Lake Kanozero.

2. Materials and methods

Lake Kanozero (67°3'33" N, 34°6'12" E, 52.7 m a.s.l.) is a large basin (area 84.3 km^2, water volume 0.27 km^3, mean depth 3.2 m, max depth 10.6 m (Resursy…,

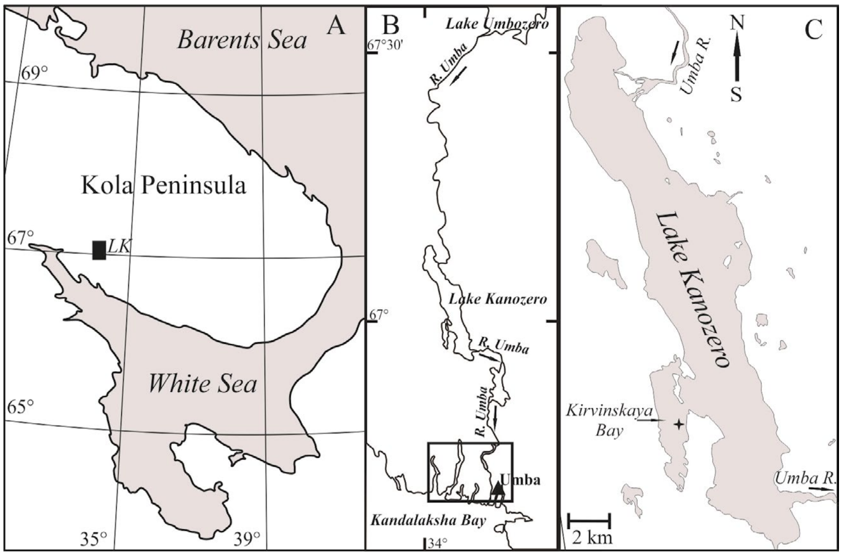

Fig.1. Location map of the study site. LK on 1A stands for Lake Kanozero; black frame on 1B indicates the area where previous isolation basin studies (Kolka et al., 2013) were performed; star on 1C indicates the sampling point.

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1970)) in the middle course of the River Umba (Fig. 1B). As the River Umba inflows to and outflows from the lake, it can be also considered a large spill on the river. The lake basin is NW-SE-oriented and has an elongated shape. The distance from its SE end to the White Sea coast is ca. 28 km.

The 3.4 m-long sediment core was retrieved from the Kirvinskaya Bay, a sheltered bay in the SW part of Lake Kanozero (Fig. 1C). Two main lithological units were described, 1) ca. 1-m thick light bluish-gray clay gradually passing into 2) 2.4-m thick greenish-brown and brown gyttja. Samples for the diatom analysis were pretreated following the standard procedure (Davydova, 1985).

3. Results and discussion

In the lower 0.4 m of the clay, resting spores of brackish and brackish-marine *Chaetoceros* spp. are the most abundant (to 60%), while other common taxa include brackish-marine *Cocconeis scutellum*, brackish *Fragilaria fasciculata* and *Rhoicosphenia baltica*, halophilous *Achnanthes haukiana*, and salinity-indifferent *Epithemia adnata* and *Rhopalodia gibba*. The proportions of the planktonic and benthic taxa fluctuate. The composition of the diatom assemblages suggests higher-salinity environments such as in a coastal zone of a freshened marine bay (Table).

Upwards, there is a narrow zone where brackish-marine *Chaetoceros* spp. rapidly decline in abundance, while brackish *Mastogloia smithii* and halophilous *Epithemia sorex* and salinity-indifferent small-celled Fragilariaceae increase. Both the proportion of benthic species and diatom concentration rapidly increase as well. The diatom record indicates decreasing salinity and depth of the basin as a result of decreased marine influence (Table). Preliminary, this transition was pollen-dated to late Allerød. The transition to freshwater conditions, however, has left no visually recognized signature in the sediment composition. Neither is could be observed in LOI values suggesting that sedimentation environments did not change accordingly.

In the upper ca. 0.55 m of the clay, brackish, brackish-marine, halophilous taxa disappear from the diatom record, and freshwater salinity-indifferent species became dominating. Benthic diatoms prevail (86-99%) with abundant small-celled Fragilariaceae (40-60%). *Amphora pediculus*, *Cocconeis neodiminuta*, *Navicula aboensis* and *Navicula jaernefeltii* are among the common taxa (Table). *Aulacoseira ambigua*, typical of lacustrine plankton is also sporadically found. The composition of the diatom assemblages points to sedimentation in the shallow-water part of a large cold-water low-productivity lake. The uppermost part of the clay unit was pollen- dated to Younger Dryas (Sapelko et al., 2022).

The diatom analysis of the uppermost part of the clay and the overlaying gyttja revealed the conditions of the shallow-water zone of a large cold-water oligotrophic basin that turned more productive with the Early Holocene climate amelioration. Subsequent water-level lowering and weakening of the water exchange between the Kirvinskaya bay and the main lake basin were also reconstructed (Sapelko et al., 2022).

The present study of the lowermost part of the sediment sequence from the Kirvinskaya Bay of Lake Kanozero revealed the evidence for the late-glacial marine transgression and subsequent isolation from the sea (Table). Thus 84.3 km^2-large Lake Kanozero represents an isolation basin with marine-lacustrine transition recorded in its sediments. Similarly, the transition from marine to freshwater environments was previously observed in the sediment and diatom records from the small semi-enclosed bay of Lake Kolvitskoye, ca. 20 km west of our study site (Ludikova and Grekov, 2017), suggesting that this large inland lake can be considered an isolation basin as well.

The lack of the isolation signal in the sediment composition in Lake Kanozero indicates that minerogenic allochthonous sedimentation proceeded in the lacustrine environments. Apparently, severe climate of the Late Glacial resulted in low productivity of the lake ecosystem.

Table. Main diatom species and reconstructed environments in Lake Kanozero

Lithology	LOI, %	Age, cal. BP	Main diatom taxa	Salinity environment
brown gyttja	39-41		*Achnanthes minutissima*, *Anomeoneis vitrea*, *A. brachysira* et var. *zellensis*, *Navicula radiosa*, *Cymbella* spp., *Pinnularia* spp., *Cyclotella* spp.	Freshwater
greenish-brown gyttja	4,5-30	9200	*Fragilaria exigua*, *Staurosira construens*, *S. venter*, *Staurosirella lapponica*, *S. pinnata*, *Aulacoseira ambigua*, *A. valida*	
light bluish-gray clay	1,9-3,2		*Fragilaria exigua*, *Staurosira venter*, *Staurosirella pinnata*, *Cocconeis neodiminuta*, *Navicula aboensis*, *N. jaernefeltii*, *Aulacoseira ambigua*	
			Staurosira venter, *Mastogloia smithii*, *Epithemia sorex*	Transitional
			Chaetoceros spp., *Cocconeis scutellum*, *Fragilaria fasciculata*, *Achnanthes haukiana*, *Epithemia adnata*, *Rhopalodia gibba*	Brackish-water

The general pattern of relative sea level (RSL) change in the coastal regions of the western part of the White Sea suggests the sea-level rise after deglaciation, followed by an early Holocene highstand and subsequent RSL fall (Baranskaya et al., 2018). Previous studies of the coastal isolation basins near Umba village, south of Lake Kanozero (Fig. 1B), revealed that the marine transgression started in the area ca. 13200 cal. BP, and lasted during the Younger Dryas till the onset of the Holocene (Kolka et al., 2013; Kolka and Korsakova, 2017). The uppermost basin where the late-glacial marine transgression was recorded is located slightly above 41 m a.s.l. It was suggested that the lake depressions located at higher elevations remained blocked by dead ice until the late Preboreal (Kolka et al., 2013). However the time of the transgression maximum and the marine limit in the area remained undetermined. Starting from the late Preboreal, the regressive trend prevailed, and ca. 10300 cal. BP the RSL dropped below ca. 41 m (Kolka et al., 2013).

Our results demonstrate that in the Late Glacial, marine waters entered the basin of Lake Kanozero, and thus the level of the marine transgression exceeded 52.7 m a.s.l., i.e. the present elevation of the lake. The marine waters penetrated as far inland along the River Umba as up to the NW end of the lake, at least, which is ca. 50 km from the present White Sea coast. Subsequently, the marine basin retreated from the depression of Lake Kanozero that resulted in the transition from brackish- to freshwater environments. Previous diatom studies also demonstrated that the lake remained freshwater during the Holocene (as summarized in Table).

4. Conclusions

1) Lake Kanozero can be considered an isolation basin as its sedimentary archive records the transition from marine to lacustrine environments at the earliest stage of its evolution. 2) The level of the late-glacial marine transgression in the area exceeded ca. 53 m a.s.l., and the sea ingressed as far inland as ca. 50 km from the present White Sea coast. 3) The signal of the isolation from the sea was not recognized in the sediment composition indicating no corresponding change in the sedimentation environment.

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Conflict of interest

The authors declare no conflict of interest.

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