Preliminary data on formation and depositional environments of lake Chaika in the central part of the Curonian Spit (Kaliningrad region, Russia, South-Eastern Baltic)

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Abstract. Lake Chaika is the only major water body present in the sand barriers of the entire territory of South-Eastern Baltic shoreline. The article provides new insights into the formation of Lake Chaika, based on data acquired through a lithological investigation of the lake sediment core combined with an organic matter content analysis, a macrofossil analysis, a radiocarbon AMS-dating and a bathymetric survey. The study revealed that Lake Chaika was formed around 500 years ago. The kettle of the lake appears to have not been submerged during the Littorina transgressions. During the mid-late Holocene, the kettle of the lake was occupied by the peat-forming ecosystems of alder carrs and sedge fens with scattered alder. The accumulation of ligneous and sedge peat occurred. The sand horizon, separating the gyttja layer from peat deposits, is considered to be a time marker for the so-called “sand disaster”, which began in the study site 200-250 years earlier than in the main territory of the Curonian Spit. There are three main formation phases of the lake’s ecosystem: the period of carrs (5390-510 cal. yr BP), the “sand disaster” period (≈550-500 cal. yr BP) and the proper lake period (500 cal. yr BP – present time).

1. Introduction
The Curonian Spit, being a UNESCO World Heritage Site, is a unique natural ecosystem, which depicts not only the beauty and course of natural processes, but also captures the significant effect that anthropogenic activities have on the environment. It is crucial in this matter to be able to reconstruct the process of development for some of its landscape areas associated with certain structural parts of the spit.

One such peculiar site is the area surrounding the village of Rybachy, where the Late Neopleistocene morainic deposits are exposed on a surface forming a plateau-like elevation in the coastal zone of South-Eastern Baltic. Lake Chaika is a remarkable water body located right in the central part of this territory (figure 1). Having an area of 0.22 km², it is the only major body of freshwater on the spit. Together with alder carrs and lowland meadows, Lake Chaika is part of a unique natural complex on the Curonian Spit, which is not found in other sand barriers on the shoreline of the Baltic Sea.
Since lake deposits are an important source of evidence for the past environmental conditions, climate change, vegetation shifts and anthropogenic activities, investigating the origin of Lake Chaika and the history of its formation can elucidate the development pattern of the natural environment in the central part of the Curonian Spit.

As a matter of fact, the aforementioned human activities played a major role in the development of the Curonian Spit. The spit became a significant transport route, this territory was subject to permanent human influence for over half a millennium. The number of settlements on the spit was higher in the past than in the present day. The massive human-induced old-growth forest clearance (17-18th cent.) was the reason for the almost complete deforestation and triggering of sand dune movement. All of this led to an event known as the “sand disaster”, after which the relief of the Spit was irreversibly and drastically changed. It was not until fairly recently that dune movement was almost entirely stopped by the construction of dykes (the alongshore foredune) and other stabilization systems. All the forests currently growing throughout the Spit are secondary or artificially planted. Taking into account the fact that Lake Chaika is located in the area of the Curonian Spit where some of the first human settlements were founded, it is highly possible that anthropogenic activity could have affected the lake ecosystem development process.

Until the present, there have been no studies addressing palaeolimnological issues for Lake Chaika. All previous investigations focused primarily on ecological status evaluation as well as the trophic, hydrochemical and hydrobiological characteristics of the lake, its flora and zooplankton [1 – 6]. Nevertheless, there are a number of issues that remain unclear, such as the shape and structure of the lake kettle, the structure of bottom deposits, the conditions of the lake’s formation, and changes to the landscape scenery in the study area during the lake ecosystem development. In order to clarify these issues, a series of field investigations has been performed, including a bathymetric survey, probing of bottom deposits and measurements of their thickness, as well as the retrieval of sediment samples for further laboratory analyses.

2. Material and methods
The research was carried out from a makeshift floating platform, assembled using a rafting catamaran (“Monya” model, Triton ltd.) as a core structure. Depth sounding was performed manually using the
labelled Russian peat corer (TBG-1 model) fitted with a probe. Taking into consideration minor depths and an excessive amount of suspended sediment material, it turned out to be impossible to perform a bathymetric survey using the echo-sounder.

The thickness of the deposits was measured by means of the Russian peat corer (TBG-1 model) equipped with a probing chamber (40 cm long, 30 mm in diameter). The measurements were made until the point of resistance (reaching the “hard” bottom and not including the upper soft layers of gyttja and peat). The measurements of the depths and bottom deposits were made in 147 points, uniformly allocated throughout the whole lake area.

After carrying out the depth sounding and estimating the topography of the kettle, a 1.46-m core of bottom deposits was retrieved in the south-western part of Lake Chaika (point Ch-2; N 55,15084°; E 20,82332°; figure 1c). The retrieval of sediment monoliths was performed with the Russian peat corer (TBG-66 model) equipped with 1-m long semicylindrical sampling chambers (50 and 75 mm in diameter). As many as 73 samples of peat and gyttja (1 cm slices) were taken from the retrieved monoliths in 1 cm increments.

The Loss-on-Ignition analysis (LOI) for each of the 73 core samples was executed using the standard methods [7].

The laboratory treatment of six peat samples was performed including an estimation of peat decomposition degree [8] and taxonomic identification of plant macrofossils in the peat. Then, the cleaned peat specimen was examined under the microscope (Micromed-3 model) to determine the taxonomic identity of plant macrofossils and estimate the percentage ratio of different plant residues in the sample. The wet peat sample was cleaned under running water on a 250-μm sieve (grid № 025K) to remove textureless humus particles. The identification of plant macrofossils in the peat was performed using a range of identification keys and guides [9 – 13].

Radiocarbon dating for three samples was performed using the accelerator mass-spectrometry method (AMS) in the Radiocarbon Laboratory of the Institute of Geography, Russian Academy of Sciences (Moscow, Russia), together with The Center for Applied Isotope Studies (CAIS), University of Georgia (USA). The obtained radiocarbon dates were calibrated using the programme CALIB (version 7.1.0 14ChronoCentre, Queens University Belfast) and the calibration curve IntCal13 [14]. All following data interpretation is based on calibrated ages.

The geological model of the lake kettle and bathymetric map have been plotted using Golden Software Surfer 11.

3. Results

3.1. Topography of the lake kettle

The bathymetric map and the kettle topography map for Lake Chaika have been generated based on the data collected from the depth sounding and the measurement of the thickness of the lake deposits (figure 2). This research was carried out to establish the best preserved natural sequences of deposits, since, in the 1980s and 2017, the lake was subject to several bottom-cleaning works, disrupting the original stratigraphy of deposits.

As shown in (figure 2), the kettle of the Lake Chaika appears to be even and flat, with its shape stretched and elongated from west to east. The maximum depth of the lake does not exceed 1.6 m, its deepest sections being a product of bottom-cleaning activities. Areas with the highest thickness of deposits (approx. 2 m.) reach a maximum depth of 0.5 m.
3.2. Structure of bottom deposits

As evidenced in the lithologic description of the sediment core from Lake Chaika (table 1), the bottom deposits may be divided into three distinct parts: the thick lower peat horizon (142–256 cm), a very thin interlayer of sand (138–142 cm) and the upper thin layer of gyttja (100–138 cm).

In order to determine the type and structure of the peat on different horizons, as well as the character of peat-forming ecosystems during different time spans, an analysis of the botanical composition of plant macrofossils in the peat was performed for 6 samples from the peat layer of the core (table 2). It enabled the team to make a preliminary reconstruction of vegetation development in the study area.

Results of the loss-on-ignition analysis for the bottom deposit samples in the Ch-2 core (figure 3) confirm the primary lithologic description (table 1).

**Table 1.** Primary lithologic description of the Ch-2 core.

| Depth from the lake water surface, cm | Lithologic description                                           |
|--------------------------------------|-----------------------------------------------------------------|
| 100 – 110                           | Leached layer of gyttja                                         |
| 110 – 131                           | Water-logged sandy gyttja, dark olive                           |
| 131 – 138                           | Water-logged sandy gyttja, pale olive                           |
| 138 – 142                           | Pale fine-grained sand                                          |
| 142 – 158                           | Moist ligneous-sedge peat, dark brown, with inclusions of sand  |
| 158 – 174                           | Moist ligneous peat, dark brown, with impurities of sand        |
174 – 188 Moist peaty gyttja, pale olive (peaty fraction is sedge fen peat)
188 – 202 Dry compact peaty gyttja with clay, pale brown
202 – 232 Dry compact ligneous-sedge peat, dark brown with content of aleuritic and clayey fractions
232 – 256 Dry compact ligneous peat, brown

Figure 3. Changes in organic matter content (shaded area represents organic matter content, dark grey is for mineral matter content).

The uppermost layer of the sediment core (100–110 cm) is formed by leached gyttja.
Deposits in the horizon (110–138 cm) consist of sandy water-logged organogenic deposition (gyttja), with the LOI values being no larger than 50% and declining with depth.
In the horizon 138–142 cm, the deposits consist of graded pale fine-grained sand, most likely aeolian-derived, with LOI being the lowest (6–17%).
Deposits beneath the sandy horizon are composed of moist ligneous peat (table 2) with an admixture of sand (142–158 cm) and clearly visible pieces of wood (branch debris). The LOI value is growing slowly with depth from 18 to 26%, indicating the gradual decrease of sand content within deposits.
The following deposits consist of ligneous peat similar to that of the previous horizon (158–174 cm), with the inclusion of sand (table 2). The LOI value increases with depth (32–48%).
In the horizon 174–188 cm, the deposits are represented by moist peaty gyttja. The peaty fraction is represented by sedge fen peat (table 2). The granulometric composition of the mineral fraction changes in this horizon from sand to aleuritic or clayey material. The inclusions of sand do not exceed 5%. The LOI value gradually declines from 40 to 30%.
The largest aleuritic or clayey fraction in deposits is found in the horizon 188–202 cm. The LOI value figures decrease to 20% and increase to 28% with depth. Unlike the previous samples, all deposits in and beneath this horizon in the core are characterised by dryness and higher density.
The underlying horizon 202–232 cm is composed of ligneous-sedge fen peat with slight inclusions of sand, 1-2% (table 2). The percentage of the aleuritic or clayey fraction starts to decrease. In turn, the organogenic fraction increases, which results in darkening of the deposits. The LOI value increases gradually from 28 to 39%.
Deposits from the horizon 232–256 cm consist of dry, compact and highly decomposed ligneous peat (table 2). The LOI value shows an essential increase on the boundary with the previous horizon from 39 to 75% and reaches 82% at the bottom of the core. Thus, the organic matter content is at its highest rate in this horizon out of the whole sediment core. At the same time, the amount of sand rises in this layer (2-10% on different horizons).
Table 2. Botanical composition of peat samples from Lake Chaika.

| Depth, cm | Degree of peat decomposition, % | Type and structure of peat | Species of plants, % | Calibrated age based on the age-depth model |
|-----------|--------------------------------|---------------------------|----------------------|---------------------------------------------|
| 155-160   | 90                             | Ligneous alder peat (with sedges and Menyanthes) Plant residues – 60%, Large branch debris – 10%, Textureless particles – 20%, Sand – 10% | *Alnus glutinosa* – 40, *Carex acuta* – 30, *Carex sp.* – 5, *Menyanthes trifoliata* – 20, *Equisetum sp.* – 3, *Betula sp.* – 1, *Drepanocladus sp.* – 1 | 1075-1225 cal. yr BP – 1300-1450 cal. yr BP |
| 165-170   | 95                             | Ligneous alder peat Plant residues – 65%, Large branch debris – 8%, Textureless particles – 20%, Sand – 7% | *Alnus glutinosa* – 77, *Menyanthes trifoliata* – 10, *Carex sp.* – 10, *Equisetum sp.* – 1-2, *Betula sp.* – 1, *Thelypteris palustris* – 1, ? *Polygonum amphibium* +, ? *Iris pseudacorus* +, *Scirpus sp.* + | 1560-1690 cal. yr BP – 1800-1930 cal. yr BP |
| 185-190   | 95                             | Sedge fen peat Plant residues – 77%, Textureless particles – 15%, Sand – 5%, Chunks of gyttja – 3% | *Carex sp.* – 65, *Menyanthes trifoliata* – 15, Unidentified residues of herbaceous – 10, *Alnus glutinosa* – 8, *Equisetum sp.* – 2, *Phragmites australis* +, ? *Typha latifolia* +, ? *Galium sp.* + | 2540-2640 cal. yr BP – 2790-2860 cal. yr BP |
| 205-210   | 95                             | Ligneous-sedge fen peat Plant residues – 85%, Textureless particles –10%, Sand – 1-2%, Chunks of gyttja – 3-5% | *Carex sp.* – 40, *Carex riparia* – 15, *Carex pseudocyperus* – 3, *Alnus glutinosa* – 27, Unidentified residues of herbaceous – 15 | 3325-3490 cal. yr BP – 3500-3695 cal. yr BP |
| 230-235   | 90                             | Ligneous alder peat Plant residues – 80%, Textureless particles – 15%, Sand – 7-10% | *Alnus glutinosa* – 93, *Carex riparia* – 5-7, Unidentified residues of herbaceous + | 4230-4520 cal. yr BP – 4405-4730 cal. yr BP |
| 245-250   | 70-80                          | Ligneous alder peat Plant residues – 85%, Textureless particles – 10-12%, Sand – 2-3% | *Alnus glutinosa* – 92, *Carex riparia* – 7, Unidentified residues of herbaceous – 1 | 4770-5135 cal. yr BP – 4950-5310 cal. yr BP |
The results of radiocarbon dating are included in Table 3. The age – depth model was plotted for Lake Chaika based on these data, (figure 4) using OxCal software v4.3.2 [15].

Table 3. Radiocarbon dating of the Ch-2 core samples.

| Description of sample | IGANAMS | Radiocarbon age, BP | Calibrated age interval for 1σ, cal BP beginning–end | Calibrated age interval for 1σ, cal BP probability |
|-----------------------|---------|---------------------|-------------------------------------------------|-----------------------------------------------|
| 1.39-1.40 cm, TOC     | 6839    | 385±20              | 340–347                                        |                                             |
|                       |         |                     | 460–499                                        | 0.135                                         |
| 1.90-1.91 cm, TOC     | 6836    | 2740±20             | 2792–2831                                      |                                             |
|                       |         |                     | 2837–2853                                      | 0.722                                         |
| 2.47-2.48 cm, Plant. rs | 6840  | 4430±20             | 4973–5022                                      |                                             |
|                       |         |                     | 5027–5044                                      | 0.755                                         |

Figure 4. Age-depth model for lake Chaika [15].

4. Discussion
Based on the lithologic description data (table 1, figure 5) combined with the chart showing changes in the organic matter content in Lake Chaika’s bottom deposits (figure 3), and taking into account the results of the macrofossil analysis (botanical composition of peat, Table 2), the radiocarbon dating of
the core samples (table 3) and the age-depth model (figure 4), we are able to reconstruct the environments which affected the formation of Lake Chaika as well as to define the main phases of development for the area of the sand plain in the centre of the Curonian Spit near Rybachy.

The reconstruction describes the environmental changes in the territory occupied by present-day Lake Chaika over the 5000 cal. years. As it is concluded from the lithologic structure of the studied deposits (table 1, figure 4), the only gyttja horizons from the upper layer of the retrieved core are referred to the proper bottom sediments of the lake, whereas, the lower peat deposits were formed during the preceding development of forest and wetland ecosystems, before the lake’s formation.

It is also worth mentioning that due to technical difficulties, glacier morainic deposits were not reached in the retrieved core, unlike those from the shallower marginal zone of the lake. It can be assumed that the core does not represent the entire sequence of deposits, and the peat horizons are underlain by moraine clay or loam beneath the retrieved core.

![Figure 5](image-url).

**Figure 5.** Macrofossil diagram combined with loss-on-ignition diagram and sequence of deposits for Lake Chaika: (1) leached gyttja, (2) sandy gyttja, (3) sand, (4) fen peat with sand, (5) swamp and fen peat, (6) peaty gyttja, (7) peaty gyttja with clay, (8) organic matter content, (9) mineral matter content.

4.1. The swamp forest and semi-open wetland complex phase (the carr period)

The structure of the lower layers of bottom sediments in Lake Chaika show the gradual transition from morainic deposits to ligneous peat. Taking into account this evidence and the data obtained through a number of palaeographic reconstructions for the area of the Curonian Lagoon [16], it could be concluded that the study site was not subjected to inundation during Littorina transgressions in the mid-Holocene.

According to our data on the lithologic structure of the sediment core and composition of plant macrofossils, this territory has been developing within the terrestrial environment over the last 5000 years. Nevertheless, its rather low location in relation to sea level encouraged the development of hydrophilic habitats in the locality.

Before the formation of Lake Chaika, the study area was presumably a shallow depression occupied by inundated alder carrs. The latter were to some extent similar to the present-day wet alder forests, growing widely across the deflation hollow area (palve) in the Curonian Spit. This is confirmed by the evidences obtained from macrofossil analysis for the lowest layers of peat (232–256
cm, ≈5390–4450 cal. yr BP) which are predominantly composed of Alnus glutinosa residues (more than 90%). The scarce remains of herbaceous plants contain rootlets of Carex riparia, a semi-aquatic hygrophyte character for the wet and regularly flooded alder carrs [17 – 18].

At the same time, Prager et al. [19] point out that remains of Carex riparia could be considered as an indicator of open vegetation on a sedge fen, meanwhile its occurrence in ligneous alder peat is, apparently, evidence of the fen peat displacement caused by the alder trees growing above which colonised the surface during the drier period. Thus, the existence of an open fen habitat could precede alder carr communities in the study area. In that case, the development of alder carrs launched more intensive peat accumulation and may have led to a formation of displacement ligneous peat containing residues of a community that existed earlier.

The overlying heavily mineralized peat layer (174–232 cm; ≈4450–2050 cal. yr BP) is markedly distinct from other horizons by the presence of gyttja. The composition of peat-forming species also changes showing a dominance of the herbaceous residues and transition from the ligneous swamp peat to the ligneous-sedge and Cyperaceae-dominated fen peat. Some clear hydrophilic plant species (Equisetum, Phragmites, Typha, Carex pseudocyperus) are recorded among the remains. The percentage of trees decreases in the sample (less than 10%). This mineralization of ligneous peat might indicate the onset of wetter conditions and the development of a more inundated open wetland community: sedge fen with a minor distribution of Alnus glutinosa.

There is an evident change in the mineral components in the horizons overlying the peaty gyttja deposits (142–174 cm, ≈2050–510 cal. yr BP): the clayey layer is replaced with sand accordingly, which appeared to be the aeolian sand that gradually blew from the dunes that suffered from deforestation (the amount of sand reaches 10% after elutriation). Once again the wood remains become dominant here (40–70%), the composition and percentage of non-arboreal residues changes to some extent (table 2) providing evidence that reflects the development of a typical wet alder carr.

Thus, during the last 5000 years (≈5390–510 cal. yr BP), the study area was occupied by peat-forming ecosystems. The fluctuations in humidity and the water regime have likely resulted in a reversible development of swamp forest complexes of alder carr and more open communities of sedge fen with a minor abundance of an alder tree layer. The latter dominated during the periods of greater inundation in the area.

4.2. The «sand disaster» period
The sand layer, separating the lower peat and the upper gyttja deposits, is most likely to be considered as evidence of the so-called “sand disaster” which occurred as a result of continuous deforestation in the Curonian Spit.

According to various authors [20 – 22], the events referred to as the “sand disaster” occurred in the 17th and 18th centuries throughout the whole territory of the Curonian Spit. However, our radiocarbon date, obtained for the horizon in the contact zone of sand and gyttja deposits, gives an age of 479.5 cal. yr BP, meaning that it can be referred to the period during 1470–1520 A.D., which is 200–250 years earlier than the established Curonian deforestation had begun [22] (figure 6). At the same time, Schlücht [20] states in his research that first occurrences of dune drift were documented in the locality near Rositten (at present Rybachy) as recently as the 16th century. It appears that across certain parts of the Curonian Spit, especially those which were the first to be inhabited, incl. Rybachy (Rossitten), the deforestation processes and dune shift took place as early as the 15th and 16th centuries. After the forests were cleared, the dunes started to drift, and the area where present-day Lake Chaika is situated, was swallowed up by moving sand in a rather short period. It caused, in turn, the dieback of the alder carrs.
Figure 6. Sketch map showing changes in forest area across the Curonian Spit, 17-18th cent. Black areas – old forest, hatched area – reforestation [22]. The study area (Lake Chaika near Rybachy) is marked by a circle.

In the territory of present-day Lake Chaika and its catchment area, the deforestation has led to water accumulation in the natural topographic depression and therefore resulted in the formation of a permanent pond. After a period of time, when forest-planting was reinforced as an attempt to stabilise the dune movement, the aeolian sand-drift declined, which caused a decrease of mineral sediment content in the bottom deposits of the lake.

It is possible that, originally, Lake Chaika had a smaller area and a different shape. Nevertheless, several cartographic data [21] suggest that the lake already existed as far back as the 1560–1570s, showing the same outlines as the present-day lake contours (figure 7).

Thus, the formation of Lake Chaika was most likely a consequence of the dieback of alder cars in the study area in the 15th and 16th centuries.
Figure 7. A map showing hideland borders near the village of Rossitten (pr. Rybachy), 1572 [21]. The coastline of Lake Chaika (Möwenbruch) matches its present day coastline.

4.3. The lake period

The beginning of the lacustrine sedimentation was related to the formation of a local water body which developed in the topographic depression, where the alder carrs previously grew. In the following years, the lake was used as a receiving water body for a drainage system, which resulted in a rise in the water level and minor coastal inundation.

The recent lacustrine deposits in Lake Chaika are represented by two layers. In the horizon 131–138 cm, the deposits consist of olive-coloured sandy gyttja, whereas in the horizon 100–131 cm, the same olive-coloured sandy gyttja has a slightly darker shade. The change in colour is presumably a result of intensified agricultural activity on the water-catchment area of Lake Chaika (the area to the south of the lake next to the Curonian Lagoon). This resulted in increasing eutrophication processes in the lake, which became a sink receiving the catch-water from draining ditches.

At present, the water level of Lake Chaika is highly unstable and can vary significantly from year to year. During a significant decrease in the water level in 2019, vast “gyttja fields” (figure 8) became exposed across shallow water areas in the lake. In the case that shallow water conditions will stay in place for an extended period of time, those “fields” might become a substrate for secondary mire formation processes and the lake’s transition into a rich-fen ecosystem. High trophic status and minor depth in this water body additionally favour the development of mire vegetation and progressive overgrowth of the coastal zone.

It is likely that these processes occurred in the past, this is indicated by historical sources [20]. According to the author, the study area was known as a bird breeding habitat with abundant colonies of seagulls, whose eggs were collected by local people. This implies a less inundated regime was required for the ecosystem. This suggestion is indirectly supported by toponymical data since the pre-war name for Lake Chaika – «Möwenbruch» – is German for “seagull mire” or “seagull swamp”, but not “lake”.

Thus, given the shallow water environment, changes in the hydrological regime of the lake over the last 500 years may have resulted in the transition of the ecosystem from an aquatic habitat to wetland and vice versa. Despite this fact, no changes in the composition of the bottom deposits (above the sand layer) were recorded, and their structure (homogenous water-logged sandy gyttja) shows a typical lake origin. This issue requires further investigations using other palaeoecological methods.

In general, the Lake Chaika of the present-day is a highly vulnerable natural site, which is dependent on changes in environmental factors as well as on anthropogenic influence on its ecosystem.

5. Conclusions
Thus, based on the results of our investigations, the following conclusions were made.

1. Lake Chaika was formed around 500 cal. yr BP, in the early modern era. The development of the lake shows three phases: the period of carrs (5390–510 cal. yr BP), the “sand disaster” period (∼550–500 cal. yr BP) and the proper lake period (500 cal. yr BP – present time).

2. The recent lacustrine environments were preceded by the long-term period of alternating peat-forming ecosystems of the alder carrs and semi-open sedge fens with scattered alder tree layer (5390–510 cal. yr BP). These communities were dominant in the area during the last 5000 years, having formed a significant layer of ligneous and sedge peat.

3. The sand horizon, separating the gyttja layer from peat deposits in the lake kettle, is considered to be a time marker for the “sand disaster”, which had begun in the study site 200–250 years earlier than in the main territory of the Curonian Spit (≈550–500 cal. yr BP).

4. The formation of the lake was influenced by two groups of factors: by environmental factors such as the presence of a wet depression on the sand plain, sufficient precipitation in the area, and by anthropogenic factors which included human-induced deforestation and airborne (aeolian) sand transport, agricultural activity and the development of a drainage system with the receiving basin in the kettle of the lake.

5. Changes in hydrological regime of the lake Chaika over the last 500 years have presumably caused subsequent alterations in the structure of the aquatic ecosystem, turning it into wetland and vice versa.

6. The kettle of Lake Chaika appears to have not been submerged during the Littorina transgressions. The kettle is even and flat in shape, its deepest depression lies at 2.4–2.5 m. The maximum depths of the lake does not exceed 1.6 m.

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