Genesis of Lakes of the City District of Dzerzhinsk City, Nizhny Novgorod Region

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Abstract. The article presents the results of research of lakes of the city district of Dzerzhinsk city, located in the Western part of the Nizhny Novgorod region, in the lowland Oka-Volga interfluve. The research was conducted in 2017-19 to research the largest lakes within the city district. Based on the results of the work, bathymetric maps of lakes were created, it’s main morphometric and hydrological characteristics were determined. On the basis of the received data hypotheses of the origin of lakes are put forward.

Introduction.
The territory of the city district of Dzerzhinsk city is located in the Oksko-Volzhsky interfluve in the West of the Nizhny Novgorod region and borders with the regional center – Nizhny Novgorod (Fig. 1).

Dzerzhinsk city is the second most populous city district of the Nizhny Novgorod region, with 231.7 thousand people living on its territory, which causes a high recreational demand for lakes. Lakes, as an important component of the landscape, reflect the landscape structure of the territory and can serve as a valuable source of information about the evolution of the host landscape. Limnological researches also reveal the relationship between the geological structure of the territory and the specifics of its relief. The possibility of involving lakes in economic use is strongly dependent on morphometric and hydrological characteristics, which are determined by the genesis of the lake and the evolution of the host landscape. Lakes have a significant economic value, and therefore are often the object of research by specialized specialists who research the hydrochemical, hydrobiological, hydrodynamic features of lakes [1, 3, 6, 7, 9]. Some of the information can be obtained from remote sensing of the Earth [4, 8], but research on the ground still plays an important role in the research of lakes. Processing of spatial data reflecting lake features is most often performed using GIS [2, 5].

The purpose of our research is to put forward a hypothesis about the genesis of lakes of the city district of Dzerzhinsk city, Nizhny Novgorod region.

Research problem:
1. Conducting bathymetric survey of lakes of the city district of Dzerzhinsk city.
2. Creation of bathymetric maps of lakes and calculation of morphometric and hydrological characteristics of lake basins.
3. Establishing the relationship between the landscape features of the territory under consideration, the structure of lake basins and their origin.

Results and Discussion.
Lakes of the Nizhny Novgorod region, including the territory of the city district of Dzerzhinsk city, are poorly researched. Some of the most notable lakes of the Nizhny Novgorod region are considered in the works of researchers of various profiles. The first scientific work devoted to the lakes of the Nizhny Novgorod region was performed by V. V. Dokuchaev, who proposed the first genetic classification of lakes. Later on, Nizhny Novgorod geologists, hydrologists, geographers, and botanists researched the

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lakes: B. I. Friedman, F. M. Bakanina, A. D. Smirnova, N. G. Bayanov, and others. Within the study area in the twentieth century, lake Pyrskoye was researched in detail, which is associated with the conduct of peat extraction (currently discontinued), as well as the conduct of geological surveys in the vicinity of the lake.

Physical and geographical conditions of the research area.

Pre-Quaternary formations are mainly represented by lower Permian deposits—siltstones, clays and marls, with inclusions of gypsum, less often—dolomites, limestones and anhydrites. A significant part of the territory is composed of Neogene deposits (sand, loam, pebbles).

Quaternary formations are mainly represented by alluvial deposits of floodplains and above-flood terraces of various horizons and are composed mainly of sand, gravel, pebbles, less often loams, clays, siltstones. Common layers of peat with a capacity of up to 11 meters. Aeolian deposits are slightly distributed.

Figure 1. Geographical location of the city district of Dzerzhinsk city

The relief is formed by extensive zander alluvial plains, alternating with numerous basins occupied by swamps and rarely lakes. The vast dune-bumpy and flat terraces of the Volga and Oka are distinguished. In those places where at a depth of several tens of meters under the permeable thickness of the sands lie gypsum and anhydrites, karst phenomena are developed. On sandy plains there is a wind-
replaced sands, creating aeolian relief; this process is especially active in localities where vegetation is disturbed. The climate is moderately continental. The largest river is the Oka, which flows along the southern border of the city district. Into the Oka flow rivers V’unica, Osovec, Gnilicka, Rzhavka. On the territory of the city district there are up to 10 rather large lakes and more than 10 small, mainly bayou lakes. Numerous reservoirs were formed on the sites of peat and sand quarries. Peat bogs occupy about 20% of the district's territory. There are swamps of all types. The soil cover is represented by sod-podzolic sandy loam soils, alluvial-sod soils of different mechanical composition are common on river floodplains, peat-swamp soils are confined to swamps. The vegetation cover is presented by pine, often with birch and rowan. In localities, ash maple and cultural breeds are widespread.

The territory of the city district of Dzerzhinsk city is characterized by intense anthropogenic impact on the landscape, however, the foci of this impact is localized, the greater part of the territory is characterized by the dominance of environment-stabilizing components of the landscape, the overall ecological stability of landscapes of the city district of Dzerzhinsk city is stable.

For setting the main characteristics of the host landscape, morphometric and hydrological characteristics of lakes and establish the genesis of lake basins in 2017-2019, a series of field researches was conducted. Bathymetric survey was carried out by echolocation method with synchronous fixation of coordinates of depth measurements points. Researched 6 lakes: Pyrskoe, V’unovskoe, Igumnovskoe, Gniloe, Yur’evskoe and Maloe Yur’evskoe. Then results, as well as stock data and remote sensing data were processed using the geographic information systems Quantum GIS 3.6.1 and Golden Surfer. The results of the work are presented in the form of bathymetric maps of lakes (maps 2-6) and a table of the main morphometric and hydrological characteristics of the lake (table 1).

Lake V’unovskoe is located in the North-West of the city district of Dzerzhinsk city, has the shape of an oval with a cutting cape in the Western part. The size of the lake is 533x501 m, the shore is steep, the coastline is slightly indented. Gniloe lake is located in the South of the city district of Dzerzhinsk city, has an elongated shape with a small bay in the Northern part. Lake Igumnovskoe is located in the South-East of the city district of Dzerzhinsk city near the Port highway, has the shape of an ellipse. The size of the lake is 346x152 m, the coastline is slightly indented. There is a strong anthropogenic influence (installed power transmission poles, on the shore of spontaneous industrial dumps are arranged). Pyrskoe lake – the second largest lake in Nizhny Novgorod region – located in the North-West of the city district of Dzerzhinsk city near the system of quarries of the peat Deposit "Pyrskoe", is oval in shape, tapering to the South. The size of the lake is 12 077 x1807 m, the coastline is weakly cut, the shore is swampy. The bottom of the lake is covered by a thickness of silt with a capacity of at least 1.5 meters. Lakes Yur’evskoe and Maloe Yur’evskoe are located in the South-East of the city district of Dzerzhinsk city in the Oka floodplain, have an elongated riverbed form. The shoreline of both lakes is slightly indented. The bottom is sandy. The lakes are connected to each other and to the Oka river by channels.

Table 1
Main morphometric and hydrological characteristics of lakes of the city district of Dzerzhinsk city

| The name of the lake   | The water surface area of lakes, m² | Volume, m³ | Shoreline Length, m | The Maximum depth of the lake, m | The Maximum width of the lake, m | Maximum water, m | Average depth, m | Average width, m | Development of shoreline | Altitude, m |
|-----------------------|-----------------------------------|------------|---------------------|---------------------------------|---------------------------------|-----------------|-----------------|-----------------|------------------------|-------------|
| V’unovskoe            | 165192                            | 1354678    | 1782                | 533                             | 501                             | 15.2            | 8.2             | 309.9           | 1.24                   | 90          |
| Gniloe                | 138359                            | 315347     | 2291                | 968                             | 271                             | 4.6             | 2.3             | 142.9           | 1.74                   | 75          |
| Igumnovskoe           | 38102                             | 10455      | 1011                | 346                             | 152                             | 0.8             | 0.3             | 110.1           | 1.46                   | 71          |
| Maloe Yur’evskoe      | 14071                             | 12570      | 878                 | 415                             | 50                              | 2.3             | 0.9             | 33.9            | 2.09                   | 66          |
| Pyrskoe               | 2389861                           | 924384     | 6323                | 2077                            | 1807                            | 1.3             | 0.4             | 1150.6          | 1.15                   | 95          |
| Yur’evskoe            | 287350                            | 980791     | 2664                | 1035                            | 436                             | 8.9             | 3.4             | 277.6           | 1.40                   | 66          |
Figure 2. Bathymetric map of lake V’unovskoe

Figure 3. Bathymetric map of the lake Gniloe
Figure 4. Bathymetric map of lake Igumnovskoe

Figure 5. Bathymetric map of lake Pyrskoye
Conclusion.

Based on the analysis of geological and geomorphological conditions, we can put forward a number of hypotheses about the genesis of lakes of the city district of Dzerzhinsk city.

Lakes Yur’evskoe and Maloe Yur’evskoe have pronounced signs of typical bayou lake: the position on the floodplain, flow and connection with the river, ruslovidnaya form of basins.

Lake Igumnovskoe, Pyrskoe and Gniloe we refer to maituga type. Maitugas are negative linear elements of relief, hollows of ancient runoff, formed as a result of the activity of meltwater flows during the melting of glaciers. This hypothesis is confirmed by a set of morphometric, geological and geomorphological features of lake basins: linear configuration with relatively small depths, location within linear, usually swampy, depressions. In addition, in the axial part of the swamp array, which is located in the lake Pyrskoe, flow rivers Pyra and Krugovishe inheriting the direction of flow of the streams of meltwater, which have developed a linear depression.

Lake V’unovskoe is considered by us as a paleothermokarstic, which is indicated by the following signs: a rounded configuration, a funnel-shaped profile, a significant depth of 15.2 meters and steep slopes of the sides of the basin. Its formation is probably related to the permafrost processes that took place during the Valdai glaciation. The territory of the Nizhny Novgorod region was then in the periglacial zone, where hydrolaccolites were formed. Climate warming in the Holocene led to the melting of hydrolaccoliths and the formation of thermokarst lakes.

The influence of karst processes on the formation of lakes of the city district of Dzerzhinsk city is not excluded. This indicates, first, the presence cartoonics rocks of early Permian age in the thickness of the pre-Quaternary formations; secondly, the presence of small and sometimes numerous sinkholes in the basins of some lakes, especially they are expressed in the basins of lakes Yur’evskoe, Maloe Yur’evskoe and Gniloe. It is not excluded that they exist on the bottom of other lakes, but powerful silt layers level the modern surface of the bottom (this is especially typical for the lake Pyrskoe).

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