Materials for the database on the largest lakes of the Kuril Islands (morphometry, genesis and geographic distribution)

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Abstract. This paper presents generalized modern data on the location, morphometry, and genesis of the largest lake basins of the Kuril Islands, obtained in a series of expeditions of the laboratory of volcanology and volcanic hazard of the Institute of Marine Geology and Geophysics FEB RAS in 2005–2020. The data is supplemented with modern geoinformation open access resources. A sample of the largest of 1099 Kuril lakes has been made according to the areal criterion, thus, 20 objects have been included in the list of studied water bodies, which are represented by 7 volcanic and 13 lagoon lakes. The considered lakes are clearly divided according to genesis, area and height of the mirror, maximum depth, as well as the ratio of the main morphometric characteristics. This information is part of a database currently being created on the largest lakes in the region.

Keywords: Kuril Islands, volcano, lake, lagoon, database, morphometry

1. Introduction
Research and assessment of water resources, their rational use are important global problems, which every year become more and more urgent for Russia. One of the main water facilities are lakes, therefore, it is necessary to constantly update data on their morphometry, spatial distribution, classification, genesis, etc., this will allow us to use our water resources most efficiently.

Considering this issue on the example of the Sakhalin Region, it can be noted that many Sakhalin lakes have been studied relatively well, while the Kuril ones have been studied either very superficially or in the context of specific issues (fishery resources, volcanological researches). In addition, most of the available information has lost its relevance and needs to be updated; the existing materials have been published in a series of articles in specialized and scientific journals, and several scientific works. In this regard, the author has set the task of generalizing the available information, creating and publishing a database on the lakes of the Kuril Islands.

2. Materials and methods
The first step in this direction was the study of the largest lakes, since they have the greatest water storage and potential for use. A review of morphometric parameters, genesis and geographical location of the largest lakes was carried out, observation results were collected and updated from expeditionary studies of the laboratory of volcanology and volcanic hazard of the IMGG FEB RAS for the period from 2005 to 2020 [1–3], as well as comparison with the materials from open access geoinformation...
resources (Google Earth, SAS.Planet) and literature data [4–7]. Field studies of volcanic reservoirs were carried out using the successfully tested method of digital bathymetric surveying with satellite referencing of profiles [1]; earlier, based on the results of the interpretation of these data, bathymetric schemes and tables of morphometric parameters of lakes were compiled, which served as the basis for creating a database.

3. Results and discussion

There are 17219 lakes in the Sakhalin region, of which 1099 are located on the Kuril Islands, the largest are volcanic lakes, as well as some lagoon ones. In order to generalize the sample of all Kuril lakes, water bodies were selected that satisfy the criteria S≥1 km² and correspond to small reservoirs according to the morphometric classification by P.V. Ivanov [9]. Using such a sample, 20 small and medium-sized water bodies of the region were selected. They are represented by 7 volcanic and 13 lagoon lakes (figure 1), all of them are clearly divided by origin, area and height of the mirror, as well as by maximum depth (table 1).

Figure 1. Location map of the largest lakes of the Kuril Islands: 1 – Goryacheye, 2 – Veslovskoye, 3 – Peschanoye, 4 – Lagunyoe, 5 – Krugloye, 6 – Dlinnoye, 7 – Krasivoye, 8 – Dobroye, 9 – Lesozavodskoye, 10 – Kuibyshevskoye, 11 – Blagodatnoye, 12 – Lebedinoye, 13 – Sopochnoye, 14 – Slavnoye, 15 – Biryuzovoye, 16 – Malahitovoye, 17 – Koltsevoye, 18 – Chernoye, 19 – Zerkal'noye, 20 – Bol'shoye.

If we consider the selected reservoirs in more detail, then we can highlight a number of important parameters, significant similarities and differences. The considered 20 lakes make up only 1.8 % of the total number of Kuril lakes, but their total area is 80.4 km², or almost 70 % of the total area of all lakes. This once again focuses the attention of the scientific community on the role of these reservoirs in the structure of water resources of the Kuril Islands. The average maximum depth of the considered lakes is 56.1 m, for lagoon lakes this indicator is 8.9 m, and for volcanic ones – 113 m. The geographical distribution of the lakes is very uneven, 14 of them are located in the Southern Kuriles, 4 in the Northern Kuriles and 2 in the Middle Kuriles, while the largest of the considered reservoirs is the Koltsevoye caldera lake located on the Northern Kuriles (Onokatan Island). According to the morphometric areal classification, the Koltsevoye Lake belongs to the middle lakes, and the other to the small ones.
### Table 1. The largest lakes of the Kuril Islands.

| №  | Island | Name            | Coordinates          | Alt. of water surf., m a.s.l. | Area of water surf., km² | Max. depth, m | Genesis | Hydrol. regime |
|----|--------|-----------------|----------------------|-------------------------------|--------------------------|----------------|---------|----------------|
| 1  | Kunashir | Goryacheye     | 43°52´ N 145°30´ E  | 128                           | 3.1                      | 62.3           | V       | DR             |
| 2  | Veslovskoye | Veslovskoye   | 43°43´ N 145°33´ E  | 1                             | 1.2                      | 1              | L       | DR             |
| 3  | Peschanoye | Peschanoye     | 43°55´ N 145°36´ E  | 5                             | 5.7                      | 21.5           | L       | DR             |
| 4  | Lagunnoye | Lagunnoye      | 44°03´ N 145°45´ E  | 1                             | 3.5                      | 23.4           | L       | DR             |
| 5  | Krugloye | Krugloye       | 44°22´ N 146°24´ E  | 8                             | 3.26                     | 5.1            | L       | EN             |
| 6  | Kunashir | Dlinnoye       | 44°24´ N 146°27´ E  | 1                             | 2.58                     | 2.8            | L       | DR             |
| 7  | Veslovskoye | Krasivoye      | 44°37´ N 147°12´ E  | 6                             | 5.8                      | 50             | V       | DR             |
| 8  | Veslovskoye | Dobrovoye      | 44°44´ N 147°14´ E  | 6                             | 2.6                      | 1.2            | L       | DR             |
| 9  | Veslovskoye | Lesozyavskoye  | 44°46´ N 147°13´ E  | 9                             | 1.45                     | 2              | L       | EN             |
| 10 | Veslovskoye | Kuibyshevskoye | 45°03´ N 147°39´ E  | 5                             | 1.4                      | 11             | L       | DR             |
| 11 | Veslovskoye | Blagodatnoye   | 45°01´ N 147°42´ E  | 4                             | 4.06                     | 15.7           | L       | DR             |
| 12 | Veslovskoye | Lebedinoye     | 45°13´ N 147°54´ E  | 1                             | 1.04                     | 3              | L       | DR             |
| 13 | Veslovskoye | Sophochnoye    | 45°18´ N 148°24´ E  | 3                             | 1.33                     | 21.5           | L       | DR             |
| 14 | Iturup   | Slavnoye       | 45°21´ N 148°44´ E  | 164                           | 2.86                     | 4              | V       | DR             |
| 15 | Simushir | Bilyuzovoye    | 46°54´ N 151°57´ E  | 50                            | 3.2                      | 87             | V       | EN             |
| 16 | Simushir | Malahitovoye   | 47°19´ N 152°27´ E  | 648                           | 1.5                      | 110            | V       | DR             |
| 17 | Simushir | Koltsevoye     | 49°20´ N 154°43´ E  | 385                           | 26                       | 369            | V       | EN             |
| 18 | Onekotan | Chernoye       | 49°34´ N 154°50´ E  | 72                            | 5.8                      | 110            | V       | EN             |
| 19 | Paramushir | Zerkal'noye   | 50°03´ N 155°25´ E  | 1                             | 1.25                     | 6              | L       | DR             |
| 20 | Shumshu  | Bol'shoye      | 50°45´ N 156°15´ E  | 2                             | 1.08                     | 1.8            | L       | DR             |

Note. V – volcanic, L – lagoon, EN – endorheic, DR – drainage.

Volcanic lakes occupy an area of 48.26 km² (60% of the total area of 20 lakes), their depth varies from several tens to several hundred meters, the average is 113 m. They are characterized by relatively high levels of the mirror – from 50 to 648 m above sea level. Lagoon lakes occupy an area of 32.15 km² (40% of the total area of 20 lakes), the depth of reservoirs is small – from 1 to 23 m, on the average 8.9 m. The absolute height of the lake surface above sea level is from 1–5 to 8–9 m.

### 4. Conclusion

The information obtained using the morphometric parameters, genesis and geographical distribution of the largest lakes of the Kuril Islands were analyzed and summarized in order to fill the database. They can be summarized in the following form:

1) There are 20 lakes on the Kuril Islands with a surface area of more than 1 km² each (1.8% of the total number of lakes in the region). The area of these 20 lakes is 80.4 km² (69.9% of the area of all Kuril lakes). The total area of volcanic lakes is 48.26 km², the maximum depths reach from several tens to several hundred meters, they are characterized by high elevations of the mirror above sea level (50–648 m). Lagoon lakes cover an area of 32.15 km² and have relatively shallow depths and minimum level markings;

2) According to the morphometric areal classification, all lakes with the exception of Koltsevoye Lake belong to small lakes, Koltsevoye lake is medium;
3) Of the 20 considered lakes, 14 are located in the Southern Kuril Islands, 4 – in the Northern Kuril Islands (the largest reservoir of the region is located here) and 2 in the Middle Kuril Islands; 7 lakes are of volcanic genesis, and 13 are of lagoon genesis;
4) The type of water exchange in the largest lakes does not depend on their geographic location and genesis. In volcanic lakes, the role of hydrothermal waters in feeding is often significant;

The tasks of further research include filling, updating and publishing the database on the Internet, as well as clarifying the list of objects, expanding the set of morphometric and limnological criteria, including data on the volumes of water bodies, their average depths, coastline ruggedness coefficients, etc.

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