Structure and inhabitants of the lakes and ponds on Uruguay Island (the Wilhelm Archipelago, Antarctica)

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SUMMARY

This paper shows the results of seasonal investigations, which were done on Uruguay Island (the Wilhelm Archipelago, Antarctica) during the period February-April 2020 on four sites. The topography of pounds' and lake's bottom was investigated with VIY3-300 GPR. Previously unknown lake under ice cap was found, its water surface was mapped and presence of water is proven by drilling. New findings of the biological organisms on the sites are described.

Introduction

Despite the fact that Antarctica is the repository of more than 70% of the world's freshwater, less of it is available in liquid form than on any other continent. Nevertheless, water bodies that contain liquid water for at least part of the year are a common feature of the Antarctic landscape. This is because water accumulates in areas where solar radiation and convection promote ice melting.

Water in Antarctica forms ponds and lakes on or under ice. Those that contain liquid water throughout the year are generally referred to as lakes while those that freeze to the base during winter (typically < 2 m deep) are referred to as ponds. Their sizes vary from tens of m^2 (small ponds) to lakes with an area of more than 10 km^2, and their depth ranges from several centimeters to hundreds of meters. The age of such water bodies can vary from a single summer to several full glacial cycles [Izaguirre et al., 2020; Laybourn-Parry, Wadham, 2014].

Lakes and ponds in the area of the Antarctic Peninsula are significantly smaller and not so remote from the human world in comparison to subglacial lakes on the Antarctic continent. However, their ecosystem also includes an amazing variety of biological communities of rotifers, ciliates, and crustacea. The prospect of analyzing these subglacial communities, their genetics and physiology, can open up a variety of questions regarding Antarctic biogeography and microbiological evolution [Doran et al., 2004].

First studies of the Argentine Islands (part of the Wilhelm Archipelago) area were done at the beginning of 20th century during French Antarctic Expedition in head with Charcot. Uruguay Island (65°14' S, 64°14' W) (fig.1) is located in the NE sector of the Argentine Islands. It was discovered in 1904 and named by Charcot as Île Uruguay [Stewart, 2011].

The first map of Uruguay Island ice cover was published after joint Ukraine-Latvia GPR (ground penetrating radar) research in February-April 2018 [Karušs et al., 2019]. The freshwater ponds and lakes of the Argentine Islands are almost unexplored. Only a few hydrobiological studies have been carried out within this region. Water bear *Barbaria jenningsi* (Dastych, 1984) was registered in a freshwater pond near the British Antarctic station of Faraday on Galindez Is. [McInnes, 1995]. Ukrainian scientist Trokhymets Vladlen has detected crustaceans *Brachinecta granulosa* Daday 1902 (Branchiopoda, Anostraca) in freshwater ponds of different islands (Galindez, Skua, Barchans Islands, etc.) and *Boeckella poppei* (Mrázek, 1901) (Copepoda, Calanoida) in a small freshwater pond of the Locator Is. from the group of Rock Islands near the Argentine Islands [Polishuk et al., 2009]. However, biologists have never studied hydrobionts of the freshwater ponds and lakes of Uruguay Is.

This paper shows the results of seasonal investigations, which were done during the period February-April 2020 on four sites. Water surface of the objects on the sites 1, 2, 3 (fig.1, B) are located on the open air (they were covered by thin ice during the survey) and object on the site 4 is under the perennial ice. After the Ukraine-Latvia GPR survey in 2018, scientists indicated a strong anomaly under the ice cap on site 4. This study is aimed on 1) precise localization of the object on the site 4, its in-situ research by drilling and biological sampling; 2) investigation of the sites 1, 2, 3.

Methods

For the study of the lakes' bottom topography and water surface indication, VIY3-300 (300 MHz) GPR was used. Settings of the survey: time-window – 330 ns, measuring step - 94 mm, 500 vertical samples, average stacking 2.1. For the interpretation, dielectric permittivity 69.2 (velocity of electromagnetic wave 36 m/mks) was considered for water and for ice dielectric permittivity - 2.27

(200 m/mks according to the drilling), 3.39 (163 m/mks [Karuss et al., 2019]). Drilling of the ice was done with research equipment made by D. Pishniak. It is a drilling device, which melts ice by heating and creates a hole 2 or 8 cm in diameter. Biological sampling was done with a net probing device. All drilling operations and biological samplings were done in accordance with The Protocol on Environmental Protection to the Antarctic Treaty and SCAR's code of conduct for the exploration and research of subglacial aquatic environments.

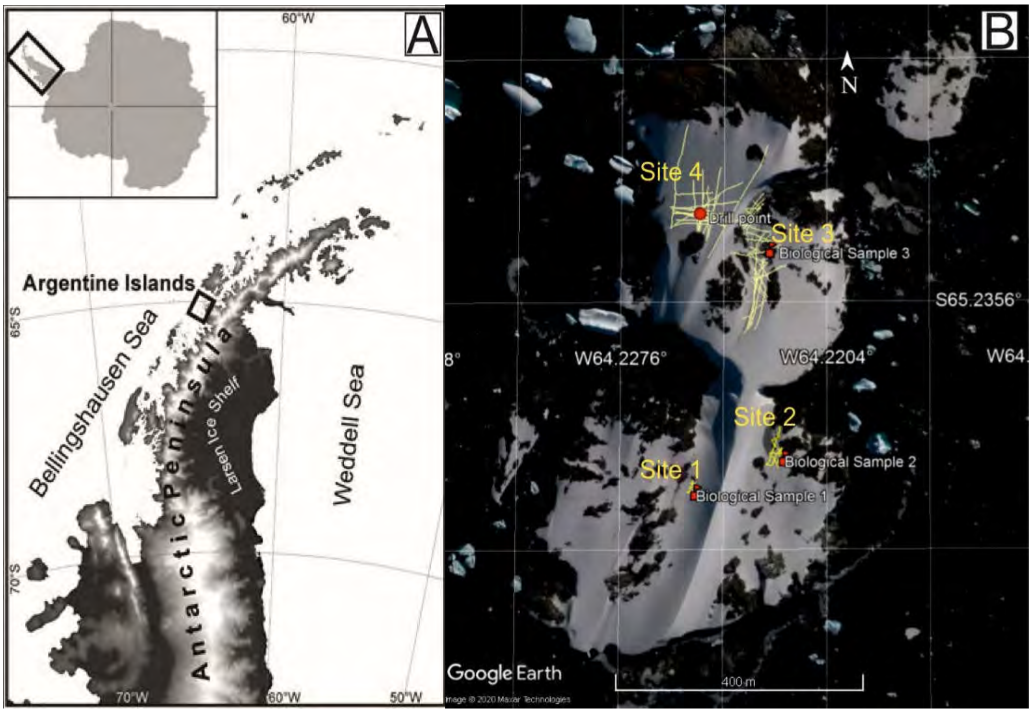

Figure 1 *Location of the surveyed sites. A – Location of the Argentine Islands (prepared using the Scientific Committee on Antarctic Research Antarctic Digital Database (ADD)). B – Uruguay Island with the names of surveyed sites; yellow lines mark GPR profiles survey directions*

Results and discussion

Firstly, GPR investigations of the sites were done to get maps of the water surface elevation changes and lakes' bottom topography (fig.2, 3). For the sites 1 and 2, the depth to the bottom is less than 1.5 meters. The water thickness on the site 3 is up to 8 meters. The deepest identified point (8.0 m) of the object 3 and several points with the depth 2-6 meters were claimed by physical measurements and depth of the reflections from bottom were calibrated according to this data. Usual number for water dielectric permittivity is 81, but for our research it is 69.2. Possibly it is provoked by low salinity (19-38 ppm) and low temperature of water (0.19-0.22°C).

The ice thickness on the site 4 according to the GPR data is 10.4 m. Comparison of the points altitude (absolute values in meters) from the GPS data helps to trace possible water channels between sites 3 and 4. An altitude of the drilling point on the snow cover is 35.9 m; an altitude of the water surface on the site 4 according to the GPR data is 25.5 m (23.5 m by drilling). An altitude of the water surface on the site 3 is 34.8 m; the absolute value of the deepest bottom point on the site 3 is 26.8 m (the depth of water 8 meters). This altitude data (fig.3, A) shows that water level on the site 3 is upper than surface of the water under ice on the site 4. According to the GPR data, there are potential water routes between the sites 3 and 4 (fig. 3, B)

GPR data shows that the object on the site 4 is not isolated system, therefore, the drilling operations and biological sampling were done according to the SCAR's code of conduct. Drilling shows the presence of water under the ice at the depth 12.4 m (0.6 m – snow-firn and 11.8 m – ice), thickness of the water is 9 m. But according to the GPR data the ice thickness was considered as 10.4 m.

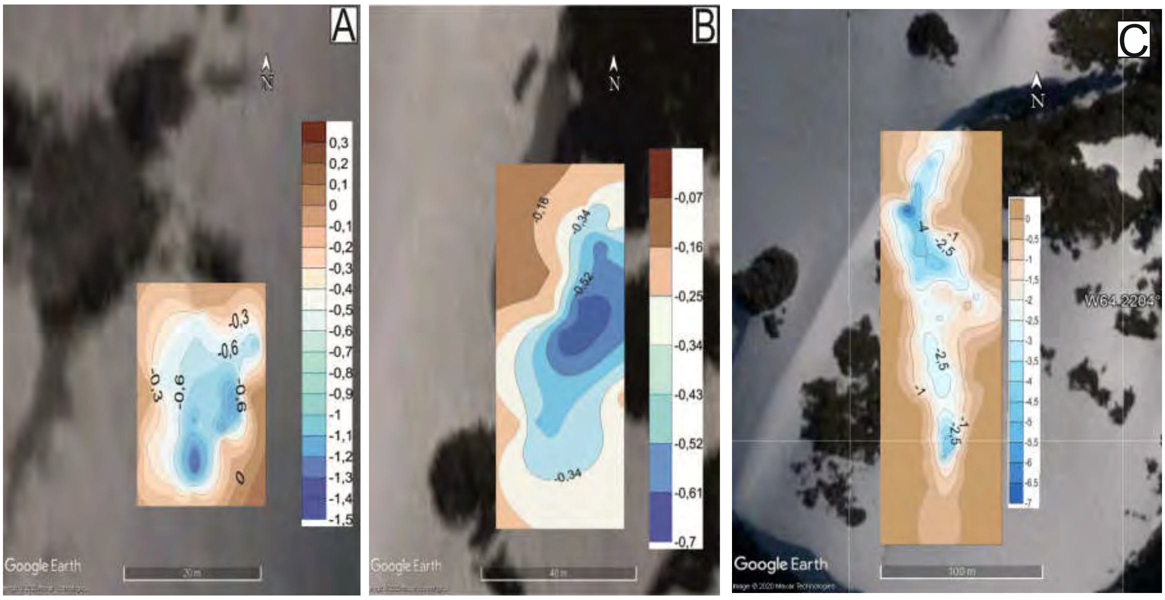

Figure 2 *Maps of the objects' bottom depth in meters. A – site 1; B – site 2; C – site 3*

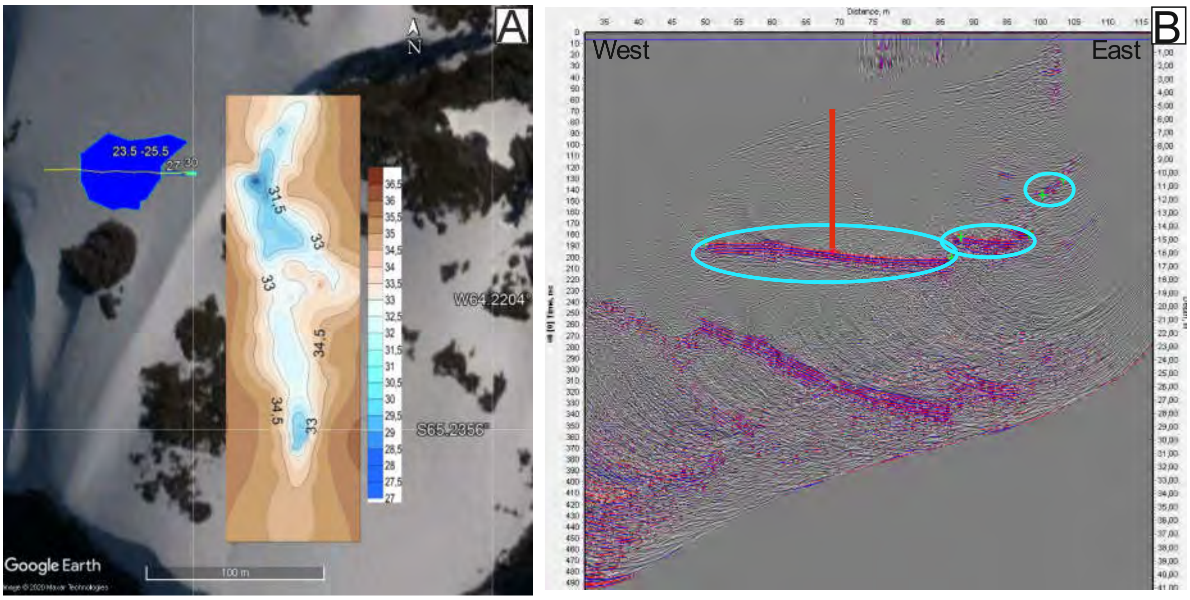

Figure 3 *Maps of the surface elevations on the sites 3 and 4. A – objects 3 and 4; yellow line marks GPR profile direction illustrated on the fig.3 B; numbers indicate the absolute level of the surfaces in meters. B – GPR profile along the site 4; red vertical line – the well; blue ovals show anomalies from water surface and water channels, their absolute level is shown on the fig. 3 A*

The GPR anomaly was registered at 130.6 ns, therefore, the velocity of electromagnetic wave is 199 m/mks (considering 12.4 m depth according to the drilling), that corresponds to dielectric permittivity of 2.27. This number of dielectric permittivity corresponds better to the snow-firn data.

There is an assumption that several meters of the ice above indicated by drilling lake were wet and so GPR reflection on more shallow depth (10.4 m, according to the previously claimed velocity 163 m/mks) was registered.
The following scientific data were obtained as a result of original biological research.
1. Biological sample 1 (Site 1, fig.1, B). Several specimens of rotifers from class Monogononta was found in the first site.
2. Biological sample 2 (Site 2, fig.1, B). Small number of crustaceans *Brachinecta granulosa* and *Boeckella poppei* was found on the second site.
3. Biological sample 3 (Site 3, fig.1, B). Many of crustaceans *Brachinecta granulosa* and *Boeckella poppei* was found in the biggest freshwater lake of Uruguay Island.
4. Biological sample 4 (drill point on the Site 4, fig.1, B). Several specimens of rotifers from class Bdelloidea were found in a glacial lake at the depth of 9 m under 12 m of ice. Also, at the bottom of this lake parts of *Brachinecta granulosa'* appendages were found.
The presence of *Brachinecta granulosa'* appendages in the water of the site 4 claims its connection with the site 3, which water level is on the open ground surface of Uruguay Island.

Conclusions

According to the obtained results and literature information, on the sites 1, 2 there are ponds and on the sites 3, 4 – lakes. But to understand if they freeze during the Winter time, monitoring of the objects should be organized.
Previously unknown lake under perennial ice on the site 4 was found and position of its water surface under the ice was mapped (fig. 3). Presence of water under the ice is claimed by drilling. Represented research shows strong evidences that lake on the site 4 is connected directly with the outer world through channels from the lake on the site 3 and biological findings also claim this assumption.
Further laboratory investigations of the biological samples should be done. Application of geophysical, biological, hydrological monitoring approaches is strongly recommended on these sites for understanding of their evolution.

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