VOL. 15, NO. 1, JANUARY 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
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SEISMOACOUSTIC RESEARCH OF LAKE BANNOE BOTTOM SEDIMENTS (SOUTH URAL, RUSSIA)

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ABSTRACT

This paper concerns the application of seismoacoustic surveying in the study of bottom sediments of Lake Bannoe, one of the lakes investigated as a part of grant 18-17-00251 of Russian Science Foundation. High-resolution seismoacoustic profiling allows remote characterization of lake sediments stratigraphy due to the recordings of acoustic waves reflected from the lake bottom. The record from bottom sediments reveals thickness of more than 6 meters where bedrocks are not possible to determine as well. This could be a result of greater thickness of sediments containing gas bubbles. However, it is clearly seen an increase in depth and decrease in sediment thickness towards the southeast.

Keywords: seismoacoustic, lake, lake sediments, South Ural.

INTRODUCTION

Seismic studies are used to carry out a wide range of different tasks, such as studying of the bottom profile of water bodies and bottom sediments, detecting sunken objects, designing various structures (pipelines, port facilities, etc.), estimating the thickness of sapropel deposits, calculating their reserves, etc. As a result of measurement system miniaturization, the method has been applied to investigate smaller water bodies, including lakes (Rudowski S., 2005). This information is of crucial significance for optimal location of coring sites with a complete stratigraphic sequence of lake sediments. Therefore, continuous seismoacoustic profiling should be routinely used prior to coring lake sediments for paleoenvironmental reconstruction (Scholz 2001).

In Russia, seismoacoustic studies are mainly carried out on large lakes such as Lake Baikal, Onega, Ladoga etc. (Akhmanov G., *et al*. 2018; Andreev, A.A., *et al.* 2019). The number of studies of small bodies of water is extremely small, due to the problem of watercraft, and suitable equipment. But the formation of deposits, even in small lakes, occurs when a multitude of factors overlap. In order to obtain core sediments that allow us to get the most complete and reliable results of paleoclimatic or paleoenvironmental studies, it is necessary to choose the core sampling points reasonably. Preliminary seismocoustic studies of small lakes can successfully solve such problems.

Lake Bannoe is one of the key sites intended for multidisciplinary investigations as a part of the grant RSF 18-17-00251. In this project three lakes were selected for high-resolution climate and environmental reconstruction of Southern Ural to identify the spatiotemporal modes of climate variability that were active during the past millennia. Having had the preliminary information about the depth of the lake, seismoacoustic survey was done prior to coring in order to determine spatial changeability of the sediment cover. Our primary and foremost goal was to locate optimal sites for coring, where retrieving a complete sedimentary sequence would be most probable.

STUDY SITE

Lake Bannoe is located on the border of the Republic of Bashkortostan and Chelyabinsk region in the middle of the Bashkir Trans-Urals between the peaks of Kutukai (664 m), Karanyalyk (620 m) and the Yamanka Ridge, 28 km north-east of the village of Askarovo and 45 km north of Magnitogorsk (53°35’18,1’’N; 58° 37’26.1’’E). The area of the lake is 7.7 km²; length - 4170 m, average width - 1880 m; the maximum depth is 28 m, the average is 10.6 m, the volume of water is 81.7 million m³, the catchment area is 36.3 km². Lake has tectonic origin. The reservoir is located at the altitude of almost 440 meters above the sea level. The water in the lake is fresh, transparent. The shores are steep, but on the west they are slightly flat. The Yangelka River, the right tributary of the Ural River, flows out of the lake.

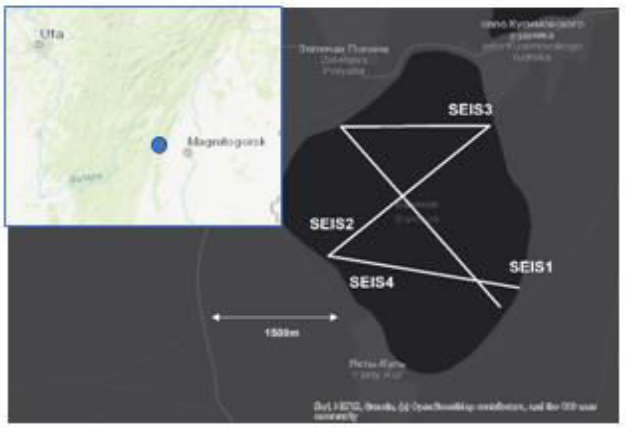

Figure-1. Location of Lake Bannoe and location of seismoacoustic profiles

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METHOD

In the present research continuous seismic profiling was applied based on the principle of central beam, which enables remote investigation of the lake bottom structure owing to the recording of acoustic waves reflected from the lake bottom. On this basis, it is possible to establish borders between sediment layers of different physical properties. The seismoacoustic profiling was carried out in 2019 using specialized complex, designed and manufactured on the base of Kazan Federal University (Krylov P. *et al.* 2015). The complex includes: a source of elastic waves, a receiver, a seismic station, a laptop, a GPS-receiver, an inflatable boat, an electric motor, and power supply elements. The complex enables us to get seismic acoustic sections with vertical resolution at least 15 cm; depth study of various types of lake sediments at least 10 m; geodetic positioning system within several meters. It also provides the digital recording of information. As a source of elastic waves an inductive oscillator "boomer" was used. A storage battery was used as a source of electric power. The GPS receiver was used to coordinate profiles and boat location (Kosareva L., et. al. 2018).

CONCLUSIONS

The analysis of the obtained seismoacoustic profiles reveals simple relationship of weakly consolidated sediments and bedrocks (Figure-2). Reflections in the uppermost layer of sediments are generally clear, but very weak. This could be a result of high-water content in surface sediments. The thickness of lake sediments (mainly laminated clays and silts) is about 6m. In the central part of section SEIS2 there is probably some gas observed in lake sediments, which masks the reflections. This could be interpreted as a bigger thickness of lake sediments. Interpolating the reflection from bedrock, it could be assumed that the thickness of the deposits reaches 7-7.5 m.

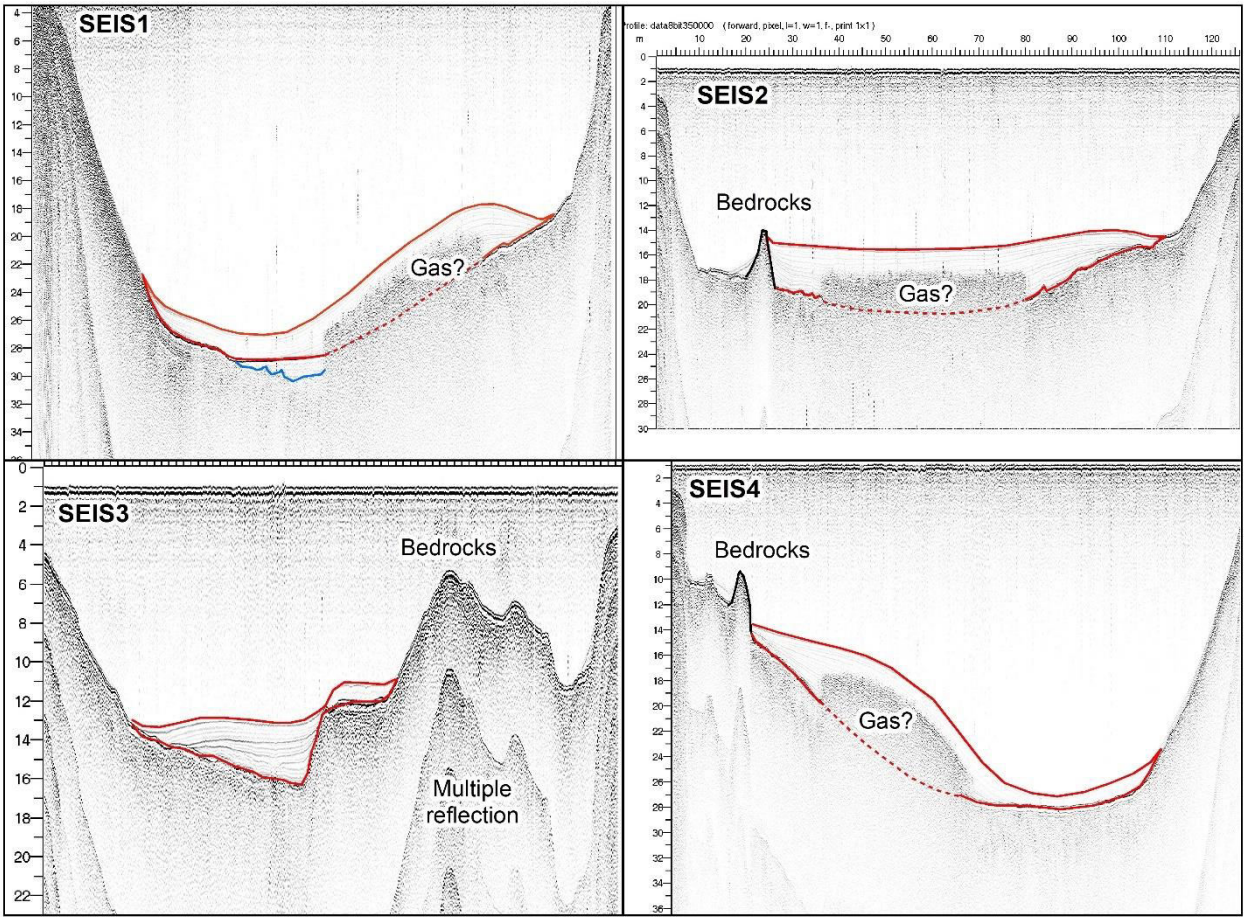

Figure-2. Four seismic sections (vertical scale - depth in meters, horizontal scale in pickets).

DISCUSSIONS

Numerous examples of seismoacoustic profiling proved its usefulness in research on both tectonic origin with great sediments thickness and postglacial lakes of small depth and sediment thickness (Scholz 2001). The accuracy of the method is sufficient to determine not only general sediment thickness, but also to resolve sedimentary horizons of different lithological features or turbidite deposits. The deposition of lake sediments on bedrock in Lake Bannoe made it possible to achieve such excellent results. The significant difference in physical properties between the sediments causes clear echo in a

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seismoacoustic record, which marks the border between base and overlying lake sediments.

In the southeastern part of Lake Bannoe, the depth reaches 28 meters; however, the thickness of the bottom sediments in this place barely reaches 2 meters. This is probably due to the flattening of the coastal part. Demolition of the material is less intense than in places surrounded by mountains. Therefore, the maximum thickness of deposits is observed towards the northeast. On seismic section SEIS1 displays reflections are marked with a blue line. The thickness of lake sediments in this part is probably greater, but acoustic energy is unable to penetrate these layers.

ACKNOWLEDGMENTS

This work was funded by the Russian Science Foundation under grant № 18-17-00251.

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