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Radioprobing of underground structure of the Failure Gulf, formed as a result of the M7.5 Tsagan earthquake

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Abstract

The Failure Gulf of the Baikal Lake was formed after a strong earthquake when dry land was lowered under the Baikal Lake water. Geoelectric characteristics of the seismotectonic structures of the studied region are described. Now the foundation of the gulf continues to depress. A border between modern bottom sediments and "paleo-soil" was revealed by means of method of radioimpedance sounding. Underground structure and electrophysical properties of the Failure Gulf of the Baikal Lake are defined.

Keywords: Baikal Lake; Resistivities; Geoelectric structure; Radioimpedance sounding; Bottom sediments

1. Introduction

The Baikal rift zone is located at the northern part of the Central Asia intracontinental deformation zone. It is the most seismoactive rift system in Eurasia. It extends over a distance of about 2000 km along the border that separates Siberian Platform from the Sayan-Baikal mobile belt. The Baikal Lake is the deepest lake in the world, containing 20% of world reserves of fresh water. Some peculiarities of geoelectric properties of seismoactive regions are common. These are the regions with active tectonics that have complex block formations. The tectonic setting of the South Baikalian test field situated within Selenga River delta area can be characterized by big and small blocks divided by a system of crossed faults. The test field was studied by Institutes of Russian Academy of Sciences. More than 300 small and strong earthquakes were fixed at the middle part of the Baikal Lake every year. The epicenter of the catastrophic Tsagan earthquake with magnitude of $M = 7.5$ was located in the territory of the test field. This very strong seismic event occurred in January of 1862 when a tectonic block of about 200 km^2 was depressed under water during one night. As the result of the earthquake the Failure Gulf of the Baikal Lake was formed.

2. Data used

To study geoelectric sections of the Earth's crust in the South Baikalian test field is of great importance to examine the physical properties of the seismogenic layer that is within 0–15 km. Fig. 1 shows all points of deep soundings carried out within the studied region. All deep works were carried out by the method of vertical electric sounding with baseline up to 16 km, transient electromagnetic sounding method using POLIGON-1 power system and magneto-telluric method (Morozova et al., 1999). According to these data it was revealed that:

1. The crustal conducting layer with resistivity of 5–50 Ω m has been identified in the Earth's crust at the depth of 10–12 km within the test field.

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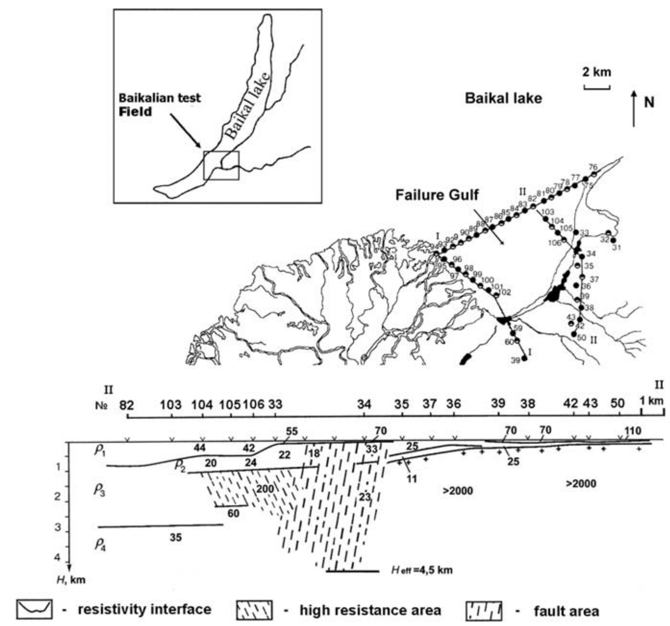

Fig. 1. Scheme of elecromagnetic sounding sites on the South-Baikalian test ground (Selenga basin) and geoelectric section on the profile II–II crossing the Failure Gulf (Morozova et al., 1999).

2. The upper part of the Earth's crust has a block structure. Faults with width of 2–4 km are filled with more conducting rocks with resistivities from 10 to 55 Ω m.

Geoelectrical sections are constructed on the basis of interpretation of data of the vertical electric sounding method and transient electromagnetic sounding method. The geoelectric section II–II across the gulf is also shown in Fig. 1. The position of the basement of the Gulf is lower than 4 km. The Delta fault with width up to 4 km is along the east-south coast of the Gulf. The fault has high conductivity of the rocks. The depth of the fault is more than 4–5 km. The north-east part of the Selenga delta block including the Failure Gulf is likely to be the area of active seismotectonic depression of the basement. Geophysical researches showed that faults that are within the Selenga basin permeate into the Earth's crust up to the upper mantle and move all intra-continental borders.

The officer of the Russian army Fedor Drizhenko has measured depths of the Failure Gulf in 1898 (Drizhenko et al., 1908). In 1958, Ladokhin (1960) drilled the bottom of the Gulf in winter on the ice with the purpose to define its depth and the recent sedimentation velocity in connection with construction of the Irkutsk Hydroelectric Power Station (HEPS) and the rise of lake level by 1.1 m. He defined that the layer of the "paleo-soil" corresponded to the former Tsagan steppe (Fig. 2). Nowadays the depth of the gulf does not essentially differ from the measurements of 1898 and 1958 in spite of the continuous of accumulation of deltoid sediments of the Selenga River. Thus, the "paleo-soil" of the former Tsagan steppe is a natural marker of the modern sedimentation in the gulf. Hence, we can make the conclusion that the immersion speed of the basement is equal to the delta sedimentation speed of the Selenga River.

3. Working procedure

The method of radioimpedance sounding is based on the study of amplitude-phase structure of an electromagnetic field in the "air-subsurface medium" border region. It allows making direct measurements of module and phase

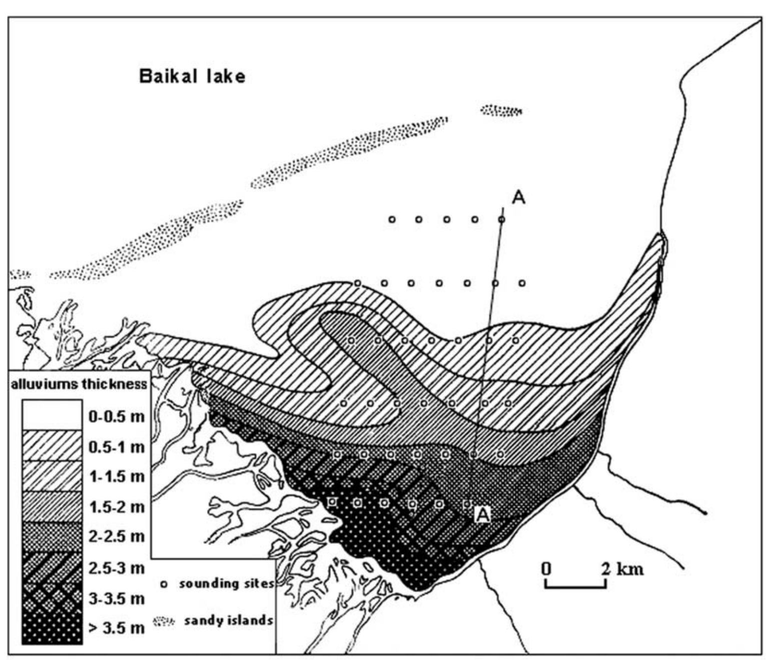

Fig. 2. The map of alluviums thicknesses at the bottom of the Failure Gulf (Ladokhin, 1960) with the scheme of radioimpedance soundings on the gulf. A–A is the basic profile, sites 1–5 correspond to drilling points made by N. Ladokhin in 1958.