On the application of shallow geophysical technologies for applied research in Kuzbass

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Abstract. The relevance application of shallow geophysical technologies has been established for applied research in Kuzbass. The main problem is formulated hindering its development. One of the main components of this problem is the lack of physical-geological models that provide heterogeneous information processing, allowing us to reliably determine the quantitative characteristics of the rock conditions. Traditional technologies of applied research are focused on discrete measurements (point) formed by a widely spaced grid of exploration lines, which make it difficult to build digital models of the rock conditions, which does not provide reliability and accuracy in determining their quantitative parameters. This approach is characterized by significant time and financial costs. The complexation of geophysical methods in Kuzbass in practice often depends on the availability of an instrument base. The work purpose is to study the application of shallow geophysical technologies for applied research in Kuzbass. The research object is the application of shallow geophysical technologies, and the subject is their features for applied research in Kuzbass. The research provides a generalization of practical experience in creating physical-geological models. The practical use is to improve the technology for collecting and interpreting geophysical information.

1. Introduction

A state analysis of the world practice of geophysical study shows that in the last decade, the highest level of them was noted in the United States and Norway when studying the shelf [1, 2, 3, 4]. The geophysical study is diverse, and it is difficult to cover it in a single article, so we will limit our consideration to shallow technologies that are of particular interest. Their demand is growing in various spheres of activity of the Kemerovo region, which is characterized by high urbanization and concentration of operations and development of mineral resources and the violation of a significant part of its territory by mining operations, which dramatically changes the natural characteristics of rock mass [5, 6]. At present, we should note the high level of development of geophysical technologies and their lower cost than drilling [7, 8, 9, 10, 11]. The demand for this information is determined by its availability, due to the successful development of the instrument base in geophysics. Currently, there are lines of devices for conducting electrical, gravimetric, magnetic, and other research.

2. Problem Statement

The main problem is that at the current development level of shallow geophysical technologies: their accuracy, efficiency, and automation degree, there are no physical and geological models that provide processing of heterogeneous information, allowing to reliably determine the quantitative
characteristics of the rock conditions. Traditional technologies of applied research are based on the passage of mining operations, most often drilling wells, which is characterized by significantly higher financial costs, as well as the research duration. Such discrete measurements from a widely spaced grid of exploration lines are point-based, making it difficult to build digital models of the rock conditions, which does not provide reliability and accuracy in determining their quantitative parameters. For example, traditional geophysics is not always effective for searching for underground water in difficult geological conditions of mountain territories and urban development. Independent application of engineering seismology methods for solving applied problems has been little studied. The progressive method of pulse electrical exploration in settlements often do not work due to strong electromagnetic interference. The complexation of geophysical methods is not fully developed in Kuzbass, and in practice, it is determined by the presence of an instrument base. The work purpose is to study the application of shallow geophysical technologies for applied research in Kuzbass. The research object is the application of shallow geophysical technologies. To achieve this goal is formulated the task of generalizing the practical experience of modeling during applied research in Kuzbass based on the application of shallow geophysical technologies. Let's look at it in more detail.

3. Materials and methods
The authors, based on the generalization of the experience of their research, taking into account [4, 7, 8, 9, 10, 11] the following groups of areas of application of applied research in Kuzbass are identified:
- explorations for the construction of new facilities;
- a survey of existing facilities (not of undermined rock mass);
- survey of the undermined rock mass;
- selection of anomalous geophysical fields as search features;
- preparation of students in geology at universities.

The authors have established the use of modeling in applied research in Kuzbass, which is as follows:
- in field and office work, characterized by a high degree of automation;
- to ensure their efficiency;
- for spatial and profile interpretation of results (Fig. 1);

![Figure 1](image)

Figure 1. Geoelectric section obtained as a result of interpretation of measurements made along the crest of the dam of the sediment pond with the profile

- in artificial outcrops to ensure the signal stability;
- the main method is tomography,
- in the most typical types of geophysical research: electric exploration, seismic exploration, and magnetic exploration.
- In the course of their practical work, the authors more often solved the following problems of physical and geological modeling at:
• seismic micro zoning of building estate;
• study of roof stability;
• study of the structure and water cut of dams.

The mathematical basis of this simulation, according to the authors, is the following criterion describing its zoning

\[ J_i \neq J_0 \]  

where \( J_i \) - the attribute under study; \( J_0 \) - its normative value.

4. Discussion of Results

Let's look at the main models in more detail on several examples. The results of the geophysical studies in the contour extraction pillar the coal bed at the mine "Siberian" and analyze obtained information the obtained model, reflecting areas forming the group of combinations of various types of stability of immediate roof and load properties of the main roof, as well as controllability classes of active roof. Also, the factors that complicate the work are identified as the presence of zones of very small disjunctive and plication dislocations with fractured and unstable, as well as very unstable siltstones of the immediate roof; the presence of stream bed erosions of coal. To prevent the development of emergencies (reducing chipping and roof collapses and caving), the recommended speed of place advance, as well as the load on the sections of the mechanical timber complex during the primary collapse of the main roof of the formation, as well as the need for measures for preliminary loosening of roof rocks.

Modeling of field measurements and interpretation of results on objects of seismic micro zoning was used by the authors based on the seismic impedance methods, including models of the measurement network and estimation of point increments. The minimum power of the calculated thickness is assumed to be 10 m, counting from the planning mark, but not more than 20 m. To calculate the seismic intensity increment by the seismic impedance method, a set of works on seismic refraction sounding was performed. Sounding was performed by the ELLISS-3 seismographic system with 24 channels with a step of 2.5 m between the channels. Seismic micro zoning was carried out by the authors in the city of Anzhero Sudzhensk to ensure the construction of new facilities.

Electrical tomography works were carried out on the crest of the dam of a sediment pond in one of the Kuzbass mines [4]. To perform field work, a multi-electrode 16-channel electrical exploration equipment "Skala-64" was used, which implements the method of electrical tomography. The equipment appearance used is shown in figure 2.

Both modeling of field investigations and interpretation of results were performed. The field investigations model is based on a geophysical profile along the crest of a dam of sediment pond at a distance of 2 to 3 m from the upper edge of the downstream slope, with a length of 157.5 m (see Fig. 1). The physical-geological model of interpretation of the results is based on the specific electrical resistance (SER), for example: throughout the profile, in the upper part of the section, up to a depth of 3÷10 m, soils with its values mainly 100÷200 OHMM are allocated, corresponding to the bulk very coarse soil of the dam body. Within this layer, at a distance of 65÷110 m from the beginning of the profile, areas of low SER (less than 80 OHMM) were identified, corresponding to areas with high soil humidity. Along the entire length of the profile, in the depth range of 3÷20 m, soils with SER are mainly 25÷50 OHMM, corresponding to the bulk loam soils of the dam body (anti filtration element). Within this layer, at a distance of 95÷115 m from the beginning of the profile, an area of low SER (less than 25 OHMM) was detected, which may correspond to increased soil humidity. In the lower part of the section, from a depth of 12÷20 m, soils with increased SER (more than 150 OHMM) are allocated, corresponding to the rock soils lying at the base of the dam. To determine the structural behaviors of soils, it is proposed to drill an engineering geological borehole with the monoliths selection and perform a studies complex of physical and mechanical properties. For well-drilling, a
site characterized by a combination of a high dam height and the smallest SER of composing soils is accepted.

![Figure 2. Equipment appearance SKALA 64](image)

5. Conclusion

Based on the research, the following conclusions are made:

1. A wide range of applied problems solved in Kuzbass based on the application of shallow geophysical technologies has been established.
2. Practical modeling in the application of shallow geophysical technologies for solving applied problems in Kuzbass is ahead of the development of their theoretical foundations.
3. To improve the efficiency of integrating geophysical methods in solving applied problems in Kuzbass, it is necessary to develop their theoretical foundations.

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