Variations in the Geoelectric Properties of the Rock Masses as a Result of the Seismic Effects of Industrial Explosions

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Abstract. In order to obtain some clarity in the matter of assessing the seismic effects from industrial explosions of the state rock massif. Variations of the electrical properties of rock mass before and after explosions were studied by electro tomography. The monitoring studies on the experimental profile selected across the strike one of the regional faults that cut across the career field of the Neryungri was conducted. Observations were made before the explosion, immediately after the explosion, and subsequent observations at intervals of one hour. The electrical resistance increases in the rock mass of tectonic disturbance on the geological structure, which located on the side of the explosion. The electrical resistance decreases in the fault zone, some changes in the electrical resistance of the hanging geological structure. It has been found that the spatial orientation of the fracturing of the rock mass affects the pattern of change in the geoelectric properties of the rock mass. The electrical properties changes in the rock mass from the location of the explosion block in concern to the direction of fracture of the rock mass. In the case when the front of the blast wave propagates along the strike of fractures, the fractures open and the intensity of moisture migration increases significantly, which involve a significant decrease in electrical resistance not only in the zone of tectonic disturbance but also in the underlying geological structure. When the wave front propagates perpendicularly to the stretch of rock mass fractures, cracks also close and moisture migration along the cracks caused by changes in the stress-strain state of the rock mass, is not significant, which is reflected in a slight change in the geoelectric properties of the rock mass in the section of the profile under study.

1. Introduction

During the development of coal deposits, geodynamic processes are activated and develop. Which leads to breach of geostatic and hydrostatic environmental conditions and negatively impact on regional and local changes in the geological environment. Geodynamic factors negatively affecting the earth’s surface are the processes of rock displacement and the development deformations of earth’s surface, and above all, the concentrated deformations in the zones of tectonic disturbances under cover sediments [1,2]. As well as impulse loads from industrial explosions on the geological environment, as a result of which there is a change in the level of natural seismicity, are initiated by technogenic earthquakes [3,4,5,6].
The physical basis for applying geophysical methods, including electrometry with artificial excitation of electrical circuits, is a 30-50% increase in the contrast of anomalous effects from ruptures, fracturing, stratification and decompression of rocks on the process of deformation concentration under the condition of continuous accumulation of elastic energy in weakened zones [2].

Electromagnetic methods are widely used to monitor the electrophysical characteristics of the rock mass, which is affected by natural and technogenic geodynamic processes. It is important to identify and track changes in the geophysical parameters of activated fault zones for the purpose of predicting destructive processes [7,8]. The intensity of variations in electrophysical parameters in one of the criteria for the activity of fractured fault structured. This criterion can be used to assess the activity of fault zones in rock mass under strong anthropogenic or seismic impact [9].

2. Studies
In order to study the influence of seismic effects from industrial explosions on the change of properties of the rock mass in the zone of influence, blasted operation conducted at mining enterprises, an experimental profile (coordinates: φ = 560 6830; λ = 124.6520) was laid in the cross of the Berkakit fault, which was mapped in the course of a large-scale geological survey of 1-50000 and considered in the V. S. Imaev and others [10], located 1-2 km from the mining company which is the largest coking coal mine in South Yakutia. This profile was used for geoelectric monitoring of changes in the electrical properties of the rock mass resulting from drilling and blasting operation in the section (figure 1).

In the process of monitoring studies, observations of changes in the geoelectric properties of rock before explosion were made. Immediately afterwards (the explosive charge capacity in both cases was about 50 tons), then at interval of 1 hour. Electrotomography method [11].

As a result of the seismic impact of the explosion, the stress-strain state of the rock mass changes, which in changes in its physical properties [12].

Figure 1. Geological map of the research area: the profile on the map is: 1 – green, the front of the mining operations – 2 – red.
The studied geological section is represented sand-siltstone difference of Mesozoic age. The most influenced electrical resistance of rocks with pressure changes is observed in sedimentary deformations. Thus, in sandstones with clay cement, the electrical resistance increases with increasing pressure. Experimentally in laboratory conditions the following features are established: the more porosity of rock and mineralization of pore solutions, the less it increases eclectic resistance with pressure growth. With a decrease in clay, the growth of electrical resistance with increasing pressure increases [13].

Geophysical monitoring of the profile was carried out in 2016-2017. Based on the result of interpretation, geoelectric sections were obtained before and after the explosion in July 2017.

Figure 2 (read from top to bottom) immediately after the explosion there is an increase in electrical resistance of the tectonic disturbance of geological structure, located on the side of explosion, because under the influence of elastic waves from the explosion. The stress-strain of the rock mass increases, which leads to an increase in electrical resistance of rocks.

Under the influence of compressive deformations of the skeleton, moisture is displaced from the pores and fractures or increasingly locked in isolated pore volumes, as a result of which the electrical resistance of the rock increases with increasing pressure [1, 14].

Regardless of the stage of epigenesis and lithology affiliation in the watered areas of the rock mass, in the areas of development of water-conducting fracturing values of electrical resistivity are reduced by 1.5-3 times compared to the background [15].

The hanging geological structure undergoes insignificant deformations in consequence of seismic effect of explosion as in a decompressed zone of fault there is a relief changes of electric resistance of the hanging geological structure are also not significant (figure 2). In due course there is a decrease in electric resistance of the deformed geological structure, as over time, after the explosion, there is a relaxation of stresses.

The geodynamic processes associated with the seismic effects of explosions on the geological environment distort the original field. Therefore, the information carrier is the difference field:

$$\Delta E = E_2 - E_1$$  \hspace{1cm} (1)

Where $E_1$ - is the initial electric field; $E_2$-electric field in the change environment. $\Delta E$ – can be represented as a field of a set of fictitious sources defined as a multiplicative function of the heterogeneity associated with the changing environment [16].

These results suggest that changes in the electrical properties of rock can serve as a precursor for earthquake prediction.

According to results of the comparative analysis, the degree of change in the state geo-environment due to seismic effect on it was estimated and established that depending on the spatial location of the epicenter of explosions, on the profile, there is difference intensity of changes in the state of the geological and geophysical environment of figure 2 and figure 3 are observed.

Some clarity due to the established ambiguity was achieved by analyzing the direction of coal-bearing rocks fracturing (figure 4). In the case when the front of the blast wave propagates along the strike of fracture, the cracks open and the moisture migration rate increases significantly, which entails a significant decrease in electrical resistance not only in the zone tectonic disturbance but also in the underlying geological structure (figure 2).

When the wave front propagates perpendicularly to the spread of rock fracture, the cracks close and the moisture migration along the cracks caused by the change in the stress-strain state of the rock mass is not significant, which is reflected in a slight change in the geoelectric properties of the tectonic disturbance zone in the section of studied profile (figure 3).
Figure 2. Changes in the geoelectric properties of rock mass due to the seismic effect of the industrial explosions on the geological environment 18 July 2017.
Figure 3. Changes of geoelectric properties of rock mass due to seismic effect of industrial explosion on the geological environment 07 July 2017.
Figure 4. Situational plan of the section – Nerungrinskaya (a); rose diagram of azimuths stretch neotectonics fractures of the Neryunri deposit (b).

3. Conclusions
Geophysical monitoring allowed to establish the development of geodynamic processes, that result in the disruption of geostatic and hydrostatic natural conditions, which has an extremely negative impact on regional and local changes in the geological environment.

Analysing the given results of seismic effect of industrial explosions of Neryunginsky section on the rock mass, it is possible to draw a conclusion that both explosions made 7 July 2017 and 18 July 2017, though are identical on power, (energetic class Kms=9.0) intensity of change of electric properties
is various. This is explained by the spatial fracture’s orientation of the rock mass. Changes in the electrical properties of rock vary highly from the position of exploding blocks of rocks in relation to the direction of fracture of the rock mass.

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