UPGROWTH OF STRONG INDUSED TECTONIC EARTHQUAKES IN CONDITIONONS OF TECHNOGENIC LOADING ACCUMULATION

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Technogenic or induced seismicity, actively evolving in conditions of intensive technogenesis, closely related to the natural tectonic seismicity. Its joint evolving and interaction presents actual scientific and technology problem due to the initiation of strong technogenou-tectonic earthquakes by means of trigger releasing of natural tectonic strains under the influence of rising external loading on geological medium.

Results of zoning of European part of Russia territory on intensity of seismic oscillation induced by mining operations and occurred due to mass explosions are presented in the paper. Analysis of upgrowth of technogenic-indused seismicity of Kuzbass territory, intensive rise of that begins in 70^{th}-80^{th} of the last century and finalized in conditions of permanently growing thechnogenous loading by Bochata catastrophic earthquake of 18 June 2013 (M=5.8-6.1), are presented in the paper too. This earthquake is happened to be the most large technogenous seismic event in conditions of mining of solid commercial minerals [Emanov et al., 2014]. Ground motion intensity in the epicenter was 7 and buildings were destroyed in the nearest cities and villages. Cities Prokopievsk, Kisilevsk, Novokuznetsk were covered by intensity of 4, and Novosibirsk and Barnaul located on the distance of 200 km were landed in 2 on Richter scale zone.

During industrialization of Kuzbass, which territory accommodate of huge stocks (about 700 billion tones) of high quality coal, technogenic loading by means of intensive underground and open-pit coal-mining was rising. Today it is executing at 52 excavating plants and 60 large mines reaching to 300 million tons per year. As it follows from the presented information permanent rise of the number and the intensity seismic events are registered simultaneously with the yearly dilation of mine explosive works. The main opinion is devoted to the upgrowth of strong thechnogenic-tectonic earthquekes of trigger character having energetic scale of K>8.5-9 and magnitude of M>3 consequently. Sources of such kind of earthquakes occur in a rock massif under changes of geomechanic and hydrologic regimes and correspond to restructuring of stress strain behavior under thechnogenic loading.

Presented information shows the confidence and relatively fast grows of technogenic loading in the period before 2000. An example the blaster agent demand for the last 10 years was grown from 100-200 thousand ton/yr to several billions ton/yr. More than that the intensive grow of plaster agent demand supplementary rises thecnogenic loading on the crust interior creating the flow of seismic energy 10^{13}-10^{14} J/yr and the energy of influence at the level of 1.5 mW.

The similar grow of thechnogenic loading in combination with the natural seismic activity was accorded by the rise of the number of induced earthquakes which includes the seismogenou-tectonic ones. By reference to seicmic catalogues of Altay-Sayan region [Yakovlav et al., 2013] and analysis of the International Seismological Centre (ISC) catalogues [Adushkin, 2015] succeed to reveal that for the period of 1963-2005 at Kuzbass territory have occurred approximately 1-2 technogenou-tectonic earthquakes M=3.5-4 per year. Its number was grows confidently to 10-20 events M=4-5 per year in the period of intensive output increase after 2006.

Mentioned rise of similar strong earthquakes was finalized by the catastrophic Bachat earthquake=5.8-6.1 and sours depth 2-14 km in the Bachat mining plant.

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ANALYSIS OF DATA ON THE MANIFESTATION OF EXTREME EVENTS DURING DEVELOPMENT OF MINERAL RESOURCES AND THEIR RELATIONSHIP WITH THE DYNAMICS OF THE BLOCKS OF THE EARTH CRUST

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Developed in Russia the method of geodynamic zoning sequentially includes identifying of hierarchical block structure of the crust of region reclamation of mineral resources or earth surface, estimating of the dynamic interaction between blocks, assessing the state of stress of blocks, developing recommendations for hazard reduction. Analysis of the data obtained during the elaboration of the dozens geodynamic zoning projects in different areas shows there is relationship on the one hand between locations of extreme events, especially rock bursts and tectonic rock bursts, earthquakes in case of flooding of mines, accidents on ingineering nets and secondly geodynamic danger zones formed by the interaction of the Earth blocks crust.

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STUDY OF ROCK SAMPLES USING LASER ULTRASONIC STRUCTUROSCOPY AND TOMOGRAPHY

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A successful geoinformation system should include a digital geomechanical model that preserves the structural features of a mineral deposit and the physico-mechanical properties of rocks. It is proposed that laser ultrasonic structuroscopy and tomography should be used to study the internal structure, porosity, and microcracks of rock samples as well as to evaluate the local elastic modulus of geomaterials. Ultrasonic wave is excited by a short laser pulse absorbed by the near-surface layer. Specially developed wideband piezoelectric transducers are used to record transmitted and scattered acoustic signals, providing information on the internal structure of geomaterials. Unlike conventional ultrasonic methods, the proposed technique employs a laser source to excite powerful wideband ultrasonic pulses in the frequency range 300 kHz to 10 MHz, with the pressure amplitude reaching 0.5 MPa. Thus, pores, microcracks, and high- and low-density heterogeneities 100microns to 1cm in size can be detected in rock samples 2mm to 4cm thick. Laser-based excitation of ultrasonic signals and the registration of scattered ultrasonic waves by a piezoelectric transducer array enable 3D imaging of the internal structure of rock samples.

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DEVELOPMENT AND UTILIZATION OF NEW GEOINFORMATIC ROCK ARRAY STRUCTURE AND PROPERTIES PREDICTION TECHNOLOGIES

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In order to predict the depth structure and properties of a rock array, a Markov tomography method has been developed that uses the results of remotely-measured areal topography changes of the Earth is surface and geologo-geophysical fields. The method, the mathematical foundation of which is the Markov finite chain theory, is based on the probabilistic inheritance of the Markov properties of depth deposits assumption by the overlaying beddings. The prognostic structure and properties of the subsurface deposits model has been calculated in the solution of the inverse problem, using computer analysis of the geologo-geophysical fields measured on the rock array surface.

The method has been proved as a program methodological complex that provides for rapid processing, interpretation, and 3D modeling of the structure and properties of arbitrary-genesis objects being studied.

The developed method has been successfully tested when conducting surface engineering and geological research on the areas of subterranean transportation and coal-methane facilities under construction that are subject to be built in rough terrain conditions, where the efficiency of surface geophysical methods application has proved to be insufficient. In this report, the efficiency of the method being proposed has been demonstrated using the Krasnaya Polyana area survey example.

Today, the issue of aggregating the developed method with the geodynamic zoning technology using satellite photographs lineament analysis data is being developed in order to increase the efficiency of remote prediction of subsurface deposits structure and properties.

SUPPORT PRESSURE ANALYSIS IN SWELLING ROCK

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Excavating in swelling rock presents some special challenges to geotechnical engineers since misjudgments in the design of support systems can lead to very costly failures. In order to understand the issues involved in the process of designing support for this type of excavation, it is necessary to examine some concepts of how a rock mass surrounding an excavation swells and how the support systems act to control this swelling deformation. Given the above, determining the induced pressure in support systems has a particular importance. In this study, we try to examine the ability of artificial neural network in combination of leave one out technique to predict the support final pressure under various initial stresses in swelling rock. The result shows that proposed method can be introduced as a suitable tool for prediction the nonlinear support pressure in swellable rock with acceptable accuracy.

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GEOINFORMATIONAL SUPPORT OF ESTIMATES AND FORECAST HAZARDOUS NATURAL PROCESSES IN MINING COAL SEAMS

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After the restructuring of the coal industry's spread widely coal face operations of coal seams on a "mine - long wall face". In addition to using high-performance equipment this led to a considerable reduction of exploited and reserve mining sites. In these conditions cardinally increases requirements for safe and efficient coal mining. One of the main problems in this direction is the identification of abnormal areas of the stress-strain state of coal rock mass. A special role is this question is in making preparations mines in outburst hazard coal seams.

Forecast anomalous zones can be done through the creation of an information model of the geological object, which allows systematize and process the scattered data about the subject and to consider it entirely or any fragment.

Detection anomalous zones allows to select mining sites hazardous gas-and-dynamic phenomena increased permeability zone, and as a result of increased gas emission, it is necessary to take into account both in the planning of mining works as well as in the degassing of coal development preparation.

GEOINFORMATION MONITORING OF GEODYNAMIC AND GAS-DYNAMIC STATE OF THE ROCK MASS.

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Using the methods of continuous geophysical monitoring (seismic, seismic acoustic) can be detected in the rock mass dynamic (seismic) lesions of the critical deformations and their relaxation (rock bumps, outbursts, collapse of roof rocks in mine workings, etc.). To identify the listed events in the automated control of geomechanical state of rock mass is developed Multifunctional control system of gas-dynamic and geodynamic condition of rock mass. Seismic sensors placed in such a way to control the space conducting cleaning and preparatory operations. Seismic acoustic sensors mounted on the roadway in front of production face at a distance of the daily movement of mining.

The data on seismic and seismic acoustic emissions are pre-processed. They are filtering, scaling, sorting. Detected seismic and acoustic signals in real time for each channel of each sensor. Determined amplitude, spectral, frequency and energy characteristics of the signals. On the identified signals determined by the coordinates of the focus range-difference method and calculates its energy.

To forecast the risk of dynamic phenomena in a coal seam is a spatial grouping of identified "hot spots" based on their energies and zones of seismic and seismic acoustic activity. Calculates the time and the place of possible adverse events. Determined by taking into account their location, the impact on the safety of mining operations on the production floor.

GEOINFORMATIC MAINTENANCE OF SAFETY OF UNDERGROUND MINING OF SHALLOW COAL SEAMS

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Technical and economic indicators in the Russian mines significantly worse than in the USA and Australian mines. Scientist were and practice explain this complicated in comparison with foreign mines mining and geological and mining conditions of occurrence of coal seams on the fields of Russia, namely a variable angle of dip within a single excavation site, the tendency of the majority of coal mining seams to shocks and sudden outbursts coal (rock) and gas; propensity to spontaneous combustion of coal seams; availability of coal mass thicker formations coal contiguous layers, improvement of which leads to the formation of high pressure areas of mining, gas reservoirs in the area of displacement and undermined above developed rock formation flooded developed spaces in the upper layers of waste and others.
In this paper we developed a model and software predict the likelihood of pre-emergency situations, the regularities of the formation of zones of increased fracturing and gas reservoir under the influence of clearing out space, offers recommendations to prevent dangerous situations.
Fundamentally new are the results of studies of the effect of non-uniform moving face on the intensity of rock pressure and dynamic allocation of methane-air mixture in the mine workings in production areas that are essential to ensure a safe technology of underground coal mines to Russian.

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CONTROLLED MAGNETIC ANOMALY APPLICATION IN TECHNOLOGY

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From the earliest times, mankind has been learning how to generate artificial magnetic anomalies, control them, and apply for separation of magnetic and non-magnetic materials in various physical states. E.g. the processes of magnetic beneficiation based on the differences in magnetic properties of the components being separated are extensively used in the processing of ferrous, non-ferrous, and rare metal ores, strong magnetic weighting-materials recovery, removal of ferric inclusion from various materials, processing of industrial wastes and secondary raw materials. Apart from utilization in magnetic separation (generation of the magnetic field), directly in the minerals processing, magnetic materials are being widely used in other industries as well. Specifically, Magnetic Resonance Imagery (MRI) and magnetotherapy find their applications in medicine, along with whole blood magnetic cell separation, bone marrow samples and mononuclear suspension separation. It is reasonable to suggest that the set of magnetic technologies utilized currently will continue its growth with the scientific progress.

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EXPERIENCE OF USE OF THE AUTOMATED LINEAMENTARY ANALYSIS OF SPACE IMAGES FOR STUDYING OF MODERN GEODYNAMICS

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For the engineering-geological characteristic of sites of city, road and underground constructions the complex of studies including surveying, prospecting and test-field and laboratory works is carried out. The special attention is paid to remote methods for studying the jointing, durability, deformability, a tension of rocks and negative engineering-geological processes use allowing the authors to obtain essentially new engineering-geological information.

For geodynamic division into blocks and identification of a block structure of the crust the method of the lineamentary analysis of space images, namely, the schemes of roses charts of local lineament (strokes) of different ranks obtained at different sizes of the sliding window has been used.

Roses charts of similar drawing are characteristic of uniform blocks. Change of drawing happens when crossing the morphostructural lineament separating heterogeneous blocks. The intense deformed condition of blocks of the crust has been estimated according to the schemes of the density of lineament (strokes). Zones of the increased density of lineament are connected with stretching conditions, and the lowered compression. The forecast of earthquakes is carried out in the lineamentary analysis of the space images obtained for several months prior to the beginning of and after an earthquake. Before an earthquake the form of roses charts naturally changes and the value of the relation of lengths of lineament of different directions. The ways of migration of fracture waters are determined by the existence of zones of the increased density of lineament (strokes) focused across river valleys. The forecast of a landslide hazard is carried out by the existence of zones of migration of the fracture waters connected with their release in the valleys of rivers.