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ROCK MASSIF OBSERVATION FROM UNDERGROUND COAL GASIFICATION POINT OF VIEW

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The Underground coal gasification (UCG) of the coal seams is determined by suitable geological structure of the area. The assumption of the qualitative changes of the rock massif can be also enabled by application of geophysical methods (electric resisting methods and geoelectric tomography). This article shows the example of evaluating possibilities of realization of the underground coal gasification in the area of the Upper Nitra Coal Basin in Cígeľ and Nováky deposits, and recommend the needs of cooperation among geological, geotechnical and geophysical researchers.

Key words: underground coal gasification, brown coal deposits, geological conditions, geomechanical and geophysical methods

Očevid krutosti tla s gledišta podzemnog otplinjavanja uglja. Podzemno otplinjavanje ugljenih slojeva određuje se stanjem geološke strukture područja. Predmnijevanje kvalitetnih izmjena krutosti tla moguće je objasniti rabljenjem elektro-geofizičkih metoda (metoda elektro otpora i geoelektro tomografija). Ovaj članak daje primjerak vrednovanja možebitne realizacije podzemnog otplinjavanja Gornje Nitranskog ugljenog bazena u ležištima Cigel i Novaki i preporučuje potrebu suradnje geologijskih, geotehničkih i geofizikalnih istraživača.

Ključne riječi: podzemno otplinjavanje uglja; ležište mrkog uglja; geološki uvjeti; geomehaničke i geofizičke metode

INTRODUCTION

Based on analysis of evolution of the geological structures it can be determined the spatial orientation of rock mass and tectonic discontinuities. Relevant are data of structure-tectonics elements, which may enable to assign the quasi-homogenous areas, i.e. the positions with similar geological characteristics.

Using of the geomechanical analysis is possible get the relevant results of physical and mechanical parameters of rock mass and stress-strain state of rock massif. The justification for the applications of the failure criteria leading us to do a proposal of the stability solution in underground spaces in real conditions and mining methods as well.

Determination of natural data of inhomogenity and discontinuation or new created broken planes in rock massif is possible to supplement by using geophysical seismic methods (e.g. seismic tomography) and electrical methods (electrical tomography). Can obtain by this methods ground information about space distribution of the discontinuation in rock massif such as their intensity as well.

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All of the procedures of analysis of the rock massif are incorporated to the basic research which is needful for each mining method and for underground coal gasification procedure as well. These analysis are unique source for creating all of research models: geological-structural, geophysical and geomechanical models of rock massif of real deposit [1, 2].

STABILITY OF ROCK MASSIF IN PROCESSES OF UNDERGROUND COAL GASIFICATION

Different of rock mass properties of coal, hanging layers and background (see Table 1) enable after mining process specified range of roll-upping origin of inter-structure of rock massif and come on to global decrease of the stability of rock massif [1].

During appropriate fire-up technology of coal seams into coal gasification processes will form the burn-out span. It is a result of burning of coal seam (just now we are solving this process by research based on physical models with temperature between 650- 900 °C [3, 4]. Burning-up space can be fill in by hanging rocks. The force of lithostatical stress can to be as the lead for subsidence of hanging. Influence of subsidence may be enhanced by existing of tectonic zone or weak zones.

Table 1. **Properties of rock mass, samples [1]**

	Hanging clay	Upper-part of coal seam	Under-part of coal seam	Background rocks
Strength /MPa	2,26 - 5,71	6,03 - 24,71	6,01 – 23,54	2,71 - 10,12
Tension /MPa	0,6 -1,28	2,15 - 2,26	1,03 -2,06	0,95
Tension by bending /MPa	2,52	5,98 - 6,24	3,20 – 5,35	0,78
Shearing test /MPa	0,85 - 2,93	3,85 - 10,70	3,13 – 8,87	0,68 – 3,93
Modulus of elasticity /MPa	311,8 - 571,9	395,3 - 853,3	502,5 -871,3	225,8 - 661,8
Poisson ratio	0,16 - 0,27	0,11 - 0,35	0,22 – 0,38	0,07 – 0,28

There knowledge facilitate projecting of optimal direction of gasifying burning of coal seam based on the real position of structural-tectonic zones.

Investigation of geomechanical properties of rock mass and rock massif from actually point of view is reflecting into different testing methods and known classification systems: Rock Quality Desigration (RQD), Rock Mass Rating (RMR), Geological Strenght Index (GSI) such as more others [e.g. 1] with practical meaning. The basis into this classification systems are of geomechanical properties, the stress-strain parameters, structural parameters and the underground water. There parameters a little precisely take a place into criteria of failure after different authors. For hard rocks are very known the criteria after Mohr-Coulomb, Hoek-Brown and Egger-Kastner [1].

Into analysis of strength parameters is most important question for determination of strength limit of non-disturbed state of rocks. Very known are tests of strength, and tensile tests of rock material. Many of authors accentuate the importance of investigation of rock mass after strength limit for similarity between broken rock mass and real discontinues into rock massif. For tensile tests are known two aspects: tensile hardness represented only 5 - 10 % of the strength, and tensile stress making the generation and raising of joints. In practice we are using the load point tests as well.

For investigation of deformation parameters such as the Modulus of deformation and Modulus of elastic are using in laboratory practice most standard uni-axial tests. The deformation state of the rock mass into the engineering calculations are idealized by known models. If more precisely we need describe to the elastic and non-elastic state than more of parameters are needed for the model and for analytic formulations these state. For example for global characterization of the stress-strain state in the rock massif is needed knowledge of more deformation parameters and others geomechanical characteristics: Poisson ratio, density of rocks, angle of friction, cohesion, porosity (permeability) state, press of water, and radial and tangential removing of rock point (after deformation). Some of this parameters are taking from geomonitoring evaluation.

GEOELECTRIC DETERMINATION OF QUALITY CHANGES AND TECTONIC DISTURBANCES

More precisely, for confirming running of faults into coal seam, are using often the technical works by boreholes and mining openings, but there are very costly and challenging from time point of view. Combination of the geomechanical analysis and geophysical methods for the determination of broken-up rock massif may be bring needful accuracy, little cost and time less [5].

In the determination of the natural discontinuities or new-creating planes of weak zones into rock massif by using of geophysical methods we obtained the basic information about spatial running of the faults and joints such as the intensity of disturbed state of layers. Most using geophysics methods are: the refractory seismic and the electric resistance profiling by using 2-layer model of rock massif [6]. Ours research experiences are showing below in the real conditions of underground brown coal seams.

GEOLOGICAL AND STRUCTURAL COMPOSITION OF COAL SEAMS IN UPPER-NITRA COAL BASIN

The background of coal seams into Upper Nitra Coal Basin, Deposits Cígeľ and Nováky (Figure 1), are building-up from Kamenske layers of Baden age, there are volcanic conglomerates, breccia and pyroclastic materials from 5 to 300 m of thickness. Handlová and Nováky layers (from Baden age) have the changeable thickness from 5 to 50 m. Alongside of coal seams there are coal clay, clay rock and thin layers of removed volcano-clastics materials. The natural volcanic layers are creating of one or two coal seams from 2,3 to 16 m of thickness. The hanging of coal seams is create of Košianske layers, there are clay and silt-clay, diatomite and diatomite clay materials from 0 to 300 m of thickness.

Volcanic activities of Vtáčnik Mt. manipulated of coal-creating sedimentation by means of tectonics mov-

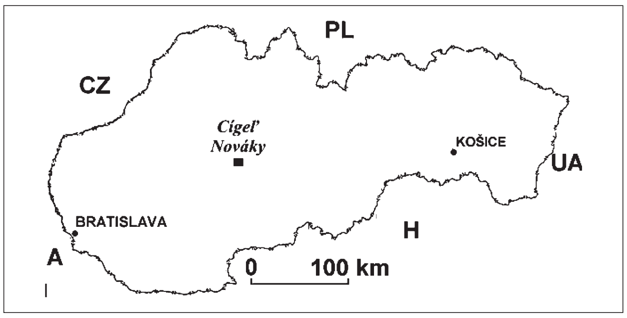

Figure 1. Place of Mine Cigel' and Nováky in the Slovak Republic

ing same of the blocks which are NE-SW ordered. Vertical amplitudes of the blocks motion are variable, between 1 cm to 100 m. It is result of the extension movement, sinking tectonic there were here active after the coal sedimentation. Bigger sink amplitudes of blocks are probably connected with sink structures of deeper base.

Into deposit area are confirmed [7] the stair-step sinks frequently coming of more tectonics zones, sometimes combined with antithetic sinks structures. Tectonics zones direction of NE-SW locally create the structures of opposite-inclined uphill and grabens.

Those structures have a relevant influence to the stability of mining gallery. The stresses which are coming to this underground works are higher near of fault. The identification of the fault in coal seams is therefore meaningful. For the identification anyone of them is the possibility to use together the geophysical methods, such as the structural-tectonics and geomechanical research.

Instability of underground spaces there are near of the tectonic faults may goes to the deformation of hanging layers which can be activated changes in underground and surface waters and after that goes to changes of the mechanical properties of rocks. The water enables roll-out of the inter-structures of sediment rocks goes to the changes of porosity and sinking of cohesion value of rock mass.

Into conditions of Upper Nitra Coal Company, in the mine Cígeľ (Figure 1) was examined the possibility of two geophysical methods. But based on a few differences of velocity of the seismic waves into coal seam and into upper and under seams of coal there are not the possibility to use the seismic methods. The knowledge that the minimum of differences of velocity for this method is 500 m/s, therefore less of this value cannot be relevant for results for the established practice [8, 9, 10].

These problems were analysed and solved by cooperation of the Geophysical Department of Technical University of Miskolc, Hungary. After the first recognition was given a proposal to the measure tectonics structures using geoelectric methods making by safeguard non-explosive area. [11, 12].

By the practical measurement were from stationary dipole of the measuring electrode removed along coal wall into gallery and takes equivalent trace of the measurement. Over there was measured difference of the electric potential between electrodes. From measured values was calculated the apparent resistance $R_u = \Delta U/I$. For the practical realization is very important that each of the electrode must be connect to the earth, into upper and under seams (not into coal seam, because it gives wrong measure). In the bigger coal seams therefore is to need achieved contact with a rounded rocks and placing this probes into the boreholes.

First step is from data-basis measurement to take a value, which represented the anomalies, i.e. the broken and non-broken area. The measurement into coal seams

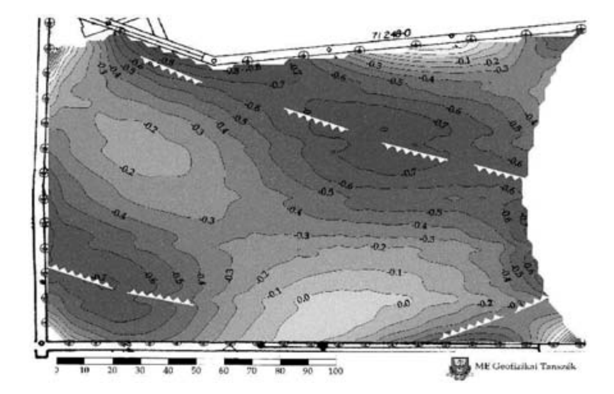

Figure 2. Resulting tomographic map from mine Cigeľ (geoelectric isolines) with inter-pretation of tectonic zones (comma-lines) [after 11]

by the geoelectric tomography has second important step. For elaborate this measured data was used computer´s programme. Based on this procedure was created the tomographic map. From this map we can localized the fault areas or the direction of tectonic lines. Results are show in tomographic map (see Figure 2). The similarly measurement was making in mine Nováky.

Based on this tomographic map were interpreted the different fault zones and showing the probably direction of tectonic lines. During the measurement such as computing of this data was not difficulties for using this method, but for precisely interpretations can play the role each of influence into measuring points, based on conditions in the real state. In the non-satisfactory density of the measuring points is resulting map for interpretation structural zones too weak.

CONCLUSION AND RECOMMENDATION

The geological, geomechanical and geophysical evaluation of the rock massif is a very important activity before, during and after mining underground works. For the global characterization of the rock massif taking big role a discontinuities (with their orientation to the axis of works, to the long-wall, ect.), there have influence to instability of the underground openings after gasification process.

Based on in situ measurement in some parts of Cígeľ and Nováky mines, on the evaluation of rock massif (going on the geological map M=1: 2 000) we are making this conclusions:

- The deposit area of NW part of mine Cígeľ is re-blockaded with different width tectonic zones almost of NE-SW direction,
- The incline of NE-SW tectonics structures is to NW such as to SE. The structures in NE-SW direction are consequence of extension of Handlova basin area, that the result goes to built synthetic and antithetic subsidences with incline to NW-SE,
- The asymmetric and different high re-placed and deformed blocks are terminating extends phase of

subsidences structures, there are the result of inter-blocks shear moving and create the different active shear zones, it takes interblocks, subhorizontal and incline deformations into massif and links to new interblocks area,

– For rock massif from UGC point of view are needed knowledges of permeability, water content such as other physical and mechanical properties of coal and rocks,
– Ours experiments show into conditions of brown coal deposists for the rock massif discontienuties (fault zones) determination is effective to use the geoelectric resistent method and the geoelectric tomography.

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