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Assessing the geomechanical state of the main working network state in the case of undermining in the conditions of weak rocks

Hennadii Symanovych[1*], Mykola Odnovol[1], Valerii Yakovenko[2], Roman Sachko[2], Iryna Shaikhlislamova[1], Tetiana Reshetilova[3], Mykola Stadnichuk[4]

[1] *Dnipro University of Technology, Dnipro, Ukraine*
[2] *PJSC "MM "Pokrovske", Pokrovsk, Ukraine*
[3] *Oles Honchar Dnipro National University, Dnipro, Ukraine*
[4] *Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine, Dnipro, Ukraine*
**Corresponding author: e-mail symanovych.h.a@nmu.one*

Abstract

Purpose. Geomechanical substantiation and determination of the parting state parameters for specific mining-geological and mining-technical conditions based on the analysis in order to substantiate the safe operating conditions of the undermined main working network.

Methods. An algorithm for studying the state of the undermined main working network includes: analysis of the texture and mechanical properties of parting rocks; mine instrumental observations of the rock pressure manifestations in the main workings; modeling of the parting state using the finite element method (FEM); calculation and analysis of its stress-strain state (SSS) with prediction of the degree of stope operations influence on possible violations of the requirements to safety rules for the main working network operation.

Findings. The texture peculiarities and mechanical properties of lithotypes around the network of main workings, the parting and the zone of future stope operations in the lower seam have been analyzed. The current state of the main workings has been studied and, together with the preliminary analysis, the rock pressure manifestations with an emphasis on the probable stope operations influence in the lower seam are predicted. For the final solution of this issue, the parameters have been substantiated and a geomechanical model of a parting behavior has been developed. Having calculated and analyzed the SSS of parting rocks, the conclusion can be drawn about the possibility of safe operation of the main working network.

Originality. New knowledge has been gained about the peculiarities of distributing SSS components in the parting, which are distinguished by its large thickness (about 100 m), but by weak strength properties of all lithotypes without exception, which are further reduced by weakening factors of fracturing, stratification and moisture from a large number of coal seams occurring throughout the height of a parting. To study the state of a parting, for the first time, a spatial geomechanical model has been validated and constructed, taking into account all the elements reflecting mining-technical situation.

Practical implications. Based on the analysis of parting SSS, the existence of its stable part with a thickness of about 37 m has been proven, which ensures the absence of the stope operations influence in the lower seam on the state of the main working network of the upper horizon, that is, the safe conditions for their operation have been substantiated. The conducted research is the basis for the development of recommendations for ensuring accident-free operation.

Keywords: *rock mass, parting, mine working, undermining, modeling*

1. Introduction

Today, the value of coal as an energy raw material is increasing in Ukraine and some European countries due to the current geopolitical situation. Coal is the main energy source material in Ukraine, the guarantor of economic and political independence, a stable basis for the production of thermal and electrical energy [1]-[4].

Despite the recent tendency towards a decrease in coal consumption and transition to alternative energy sources, this energy source material is of strategic importance for the country, since about 35% of electricity generation comes from thermal power plants [5]. Therefore, despite certain environmental troubles, the problem of increasing the volume of coal production or, at least, preventing its decrease, is becoming an urgent one [6]-[8].

This main factor in the Western Donbas conditions borders on some others, namely: completeness of mining of already prepared coal reserves, which reduces its production cost; maintaining the mine production capacity by mining of new horizons with predominantly off-balance reserves; preservation of jobs while improving social conditions in the region [9], [10]. It should also be taken into account that coal enterprises are budget-generating for many mining regions [11]-[14].

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The problem of resource saving in the mining of seams is extremely relevant in current conditions of conducting coal mine operations [15]-[19]. This is particularly true in the case of intensive growth in the volume of mineral mined, which leads to an increase in the mining depth and complicates the geomechanical conditions of mining operations [20]-[22]. In this sense, it has a scientific and practical perspective to substantiate the possibility of safe operation of the network of main workings when they are undermined in the lower seam, which ensures the introduction of new production capacities [23], [24]. This issue is very important, as it concerns the safety of the entire mine horizon operation. Therefore, taking into account the above, a complex research methodology has been developed, followed by an algorithm for its phased implementation.

2. Research methodology

The prerequisite for the entire research is the analysis of the texture and mechanical properties of the rocks of a particular area in the Zakhidno-Donbaska mine field of the Mine Administration "Ternivske", PJSC "DTEK Pavlohradvuhillia". This analysis was conducted according to the geological information provided for selected wells located near the main working network of the C_8^b seam, namely, No. 14241, No. 14335, No. 15110, with averaging the thickness of the rock layers and coal seams. With regard to the mechanical properties of lithotypes, the Geological Survey data from the Mine Administration "Ternivske", the results of testing the rock samples at the Institute of Geotechnical Mechanics named by N. Poljakov National Academy of Sciences of Ukraine, as well as generalization of studies [25] for the Western Donbas conditions, are used.

The experience studied and results of studies on the parting state during the simultaneous mining of several coal seams in the Western Donbas [26], [27], as well as in other coal-bearing regions [28]-[33], prove the high effectiveness of using numerical methods and, in particular, FEM. Usually, spatial geomechanical models are constructed [34]-[39], which make it possible to obtain curves of the SSS components in any rock mass section. Particular attention is paid to the reflection of the texture transformations in the coal-overlaying formation of the mined-out area, modeling of contact disturbances of adjacent lithotypes, as well as determination of the rock weakening and destruction zones. The following studies [40]-[44] are very useful here. In general, based on the analysis of the results of modern studies in this area, an algorithm for studying the state of a parting within the C_8^b and C_5 seams has been constructed and implemented.

An obligatory methodological component of improving the adequacy and reliability of the final results was detailed instrumental observations [45]-[49] of all main workings of the C_8^b seam, which are included in the list of research objects. The peculiarities of the rock pressure manifestations are systematized, and a proper understanding of their occurrence is given through the mechanism of occurrence and development of geomechanical processes: mainly vertical, obliquely directed and lateral pressure, the pressing of the frame support prop stay bearings into the rocks of the mine working bottom, and in some places the complete loss of their operating condition. At the same time, it is necessary to note the predominantly satisfactory state of the mine workings, where the residual plane of their cross-section is usually 10-15 m^2 and does not violate the requirements for proper horizon ventilation and safety rules for motor-vehicle traffic and people movement.

The above research stages form the basis for substantiating the parameters and creating a sufficiently adequate geomechanical model for the parting behavior with already mined-out C_8^b seam reserves and the beginning of mining the C_5 seam. Based on the results of the calculation and analysis of the SSS components, the zones of weakening of the parting rocks and the areas of their stable state have been determined, as well as the main conclusion has been substantiated on the possibility of further safe operation of the main working network under the condition of implementation of local current repair and restoration works.

In accordance with the developed methodology, the prescribed research stages are consistently performed. As a result of the analysis of the texture and mechanical properties of the parting rocks of the C_8^b and C_5 seams, Table 1 has been compiled, which gives the main lithotype parameters used to construct a geomechanical model that reflects the parting state.

Table 1. Average parameters of texture and mechanical properties of the parting rocks in the C_8^b and C_5 seams

Lithotype	Thickness, m	Compressive resistance in the sample σ_{compr}, MPa	Calculated compressive resistance R, MPa	Elasticity modulus $E \cdot 10^4$, MPa
Coal seam C_8^b	0.9	40.0	11.5	0.35
Argillite	3.6	14.6	3.1	0.20
Coal seam C_8^{b0}	0.3	30.0	12.0	0.35
Argillite	3.2	14.6	6.2	0.40
Coal seam C_7^{top}	0.5	30.0	12.0	0.35
Argillite	3.7	14.6	3.1	0.20
Coal seam C_7^b	0.6	30.0	12.0	0.35
Argillite	13.8	14.6	6.2	0.40
Siltstone	4.8	15.3	9.8	1.00
Argillite	8.1	14.6	8.8	0.50
Siltstone	9.4	15.3	9.8	1.00
Argillite	7.5	14.6	8.8	0.50
Siltstone	14.2	15.3	9.8	1.00
Coal seam C_6^{top}	0.45	30.0	12.0	0.35
Argillite	1.0	14.6	13.1	0.20
Coal seam C_6^b	0.45	30.0	12.0	0.35
Siltstone	8.9	15.3	9.8	1.00
Sandstone	6.7	20.1	11.6	1.80
Siltstone	5.0	15.3	9.8	1.00
Argillite	9.1	14.6	8.8	0.50
Coal seam C_5	0.8	40.0	11.5	0.35

The total parting thickness is 102.0 m, which, according to preliminary assessments, eliminates the stope operations influence in the C_5 seam on the network of main workings in the C_8^b seam. However, the scientific basis for this point of view has been provided by modeling the state of a parting using the FEM. Therefore, the properties of lithotypes forming the parting of the C_8^b and C_5 seams have been studied in more detail.

3. Research results

In accordance with the developed methodology, the prescribed research stages are consistently performed. As a result of the analysis of the texture and mechanical properties of the parting rocks of the C_8^b and C_5 seams, Table 1 has been compiled, which gives the main lithotype parameters used to construct a geomechanical model that reflects the parting state.

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The C_8^b coal seam with a thickness of 0.9 m, compressive strength in the sample $\sigma_{compr} = 40$ MPa, moistened, fractured, and has a weak coherence with the rocks in the immediate roof and bottom. Due to moistening and intense fracturing, the C_8^b seam calculated strength decreases in accordance with [50] to $R = 11.5$ MPa. The elasticity modulus $E = 0.35 \cdot 10^4$ MPa is chosen according to the results of studies at the Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine, as well as based on the work [25].

The argillite is massive, with horizontal stratification, 3.6 m thick and a compressive strength in the sample $\sigma_{compr} = 9.0\text{-}20.1$ MPa. The calculated compressive strength averages $R = 3.1$ MPa due to moistening from the C_8^b seam, stratification, fracturing, and rheological properties. The elasticity modulus is chosen to be $E = 0.20 \cdot 10^4$ MPa.

Coal seams C_8^{b0}, C_7^{top}, C_7^b, C_6^b have the same mechanical characteristics: ultimate compressive strength in the sample is $\sigma_{compr} = 30$ MPa, calculated compressive strength is $R = 12.0$ MPa, elasticity modulus is $E = 0.35 \cdot 10^4$ MPa; all seams are ultra-thin seams with a thickness ranging from 0.3 m to 0.6 m, with very weak coherence with adjacent rock layers.

The argillite forming the C_8^{b0} seam bottom has a thickness of 3.2 m with an ultimate compressive strength $\sigma_{compr} = 9.0\text{-}20.1$ MP, but it is not significantly moistened, with reduced fracturing intensity; therefore, it has an increased calculated compressive resistance $R = 6.2$ MPa and an elasticity modulus of $E = 0.40 \cdot 10^4$ MPa. The argillite in the C_7^b seam immediate bottom has similar mechanical properties, as its large thickness of 13.8 m contributes to the absence of moisture throughout the entire thickness.

In contrast, the argillite occurring between the C_7^{top} and C_7^b seams is probably moistened throughout its entire thickness of 3.7 m; therefore, for this lithotype, $R = 3.1$ MPa, $E = 0.20 \cdot 10^4$ MPa.

The C_7^b coal seam main bottom is composed of micaceous and fine-grained siltstone with a stratified texture. Its thickness is 4.8 m with an ultimate compressive strength in the sample $\sigma_{compr} = 9.5\text{-}21.1$ MPa. Low moistening causes the calculated compressive strength $R = 9.8$ MPa, and the elasticity modulus is $E = 1.0 \cdot 10^4$ MPa. Siltstones with similar mechanical properties also occur below, up to the C_5 coal seam.

In this segment of a parting, argillite layers appear, which have reduced fracturing and a natural moistened state. Therefore, their calculated compressive resistance ($R = 8.8$ MPa) and elasticity modulus ($E = 0.50 \cdot 10^4$ MPa) increase.

As a result, fine-grained sandstone, moistened on clay-limestone cement and fractured occurs in the seam C_5 main roof. It has a thickness of 6.7 m, but a small compressive resistance in the sample $\sigma_{compr} = 20.1$ MPa; therefore, its calculated compressive resistance is only $R = 11.6$ MPa, and the elasticity modulus is $E = 1.80 \cdot 10^4$ MPa. The performed analysis of the texture and mechanical properties of the parting lithotypes in the C_8^b and C_5 seams is used in the construction of its geomechanical model and calculation of SSS.

The task of studying the SSS of a parting in the C_8^b and C_5 seams has the ultimate purpose to answer the question – whether the main working network state of the C_8^b seam will be influenced by the stope operations in the 518 longwall face and in other extraction sites of the C_5 seam? That is, whether the disturbances of the C_5 seam roof rocks will develop to the C_8^b seam (taking into account the disturbances of its bottom from the stope operations of the past)? To do this, it is necessary to study the state of the parting rocks, to identify the zone of weakening and a holistic zone, which will restrain the displacements in coal-overlaying formation into the mined-out area of the C_5 seam. A geomechanical model (Fig. 1) has been substantiated and constructed to solve the questions posed.

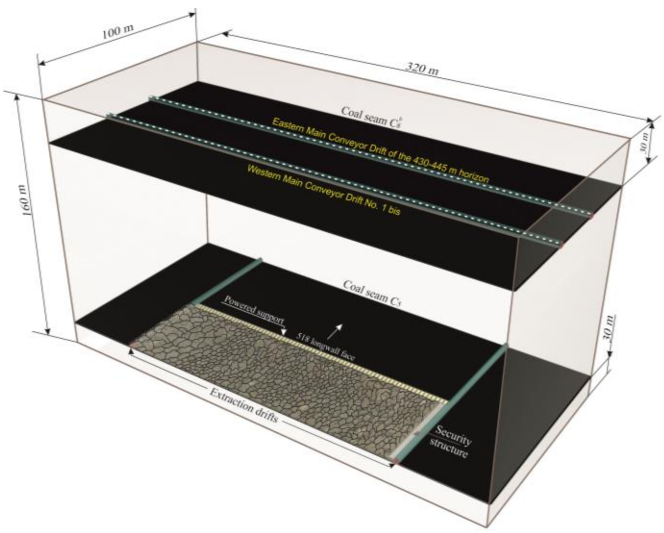

Figure 1. Model of undermining the main working network of the C_8^b seam with the 518 longwall face of the C_5 seam

As a matter of fact, the research purpose is that the geomechanical model should be spatial, because it necessarily includes:

– the main working network of the seam C_8^b; the entire network is located approximately at the same distance from the C_5 seam, then it is enough to model two mine workings, for example, the Western Main Conveyor Drift No. 3 (WMCD No. 3) and the Eastern Main Ventilation Drift (EMVD) of the 420-445 m horizon;

– the C_8^b seam roof is modeled to a height of up to 30 m – this is necessary to eliminate distortions in the distribution of SSS components associated with the imposition of boundary conditions on the upper horizontal surface of the model (*XZ* plane); then the state of the parting rocks will be determined as adequately as possible;

– for similar reasons, the C_5 seam bottom is also modeled to a depth of 30 m;

– seam C_5 is modeled at a depth of 102 m from seam C_8^b, which characterizes the average parting thickness according to data of a number of geological wells; given the seam C_8^b roof height and the seam C_5 bottom depth, the total geomechanical model height is $Y = 160$ m;

– in the C_8^b seam, the actual distance of approximately 35-40 m between the WMCD No. 3 and EMVD of the 420-445 m horizon is shown; on their sides, a sufficient distance to the vertical model boundaries is modeled (to avoid SSS distortions), but the main factor to substantiate the model width according to the *X* coordinate is the stope operations in the C_5 seam 518 longwall face;

– the experience of modeling stope operations indicates a sufficient size along the extraction site length X of 100 m, which completely encloses the frontal bearing pressure zone ahead of the 518 longwall face and the stabilization zone of the coal-overlaying formation displacement processes into the mined-out area after the 518 longwall face is mined out; thus, the model size is taken as $X = 100$ m;

– along the 518 extraction site length, the following are necessarily modeled: extraction drifts (prefabricated and boundary), powered support of the stoping face, mined-out area with rocks of the uncontrolled collapse and hinged-block displacement zones, security system with appropriate resistance to rock pressure;

– the size of the model along the strike (Z coordinate) is determined by the following factors: the length of the 518 longwall face, the width of both extraction drifts, the width of the virgin mass zones, sufficient to eliminate SSS distortions; in general, the acceptable size of the model along the strike is $Z = 320$ m.

The texture and mechanical properties of the lithotypes forming the partings of the C_8^b and C_5 seams are shown in Table 1. The traditional boundary conditions are taken for the rock mass SSS geomechanical studies, that is, there is an applied vertical geostatic pressure on the upper face:

$$\sigma_y = \gamma H, \tag{1}$$

there is a rigid bearing on the lower face, and horizontal geostatic pressure acts on the side surfaces:

$$\sigma_x = \sigma_z = \frac{\mu}{1-\mu}\gamma H, \tag{2}$$

where:

γ – weight-average unit specific gravity of the coal-overlaying formation rocks;

H – depth of mine working location;

μ – coefficient of transverse rock deformation.

According to the given spatial geomechanical model, a computational experiment is performed, as a result of which the distribution curves for the main stress components in the parting of the C_8^b and C_5 seams are constructed. The SSS analysis is performed for all main stress components: vertical σ_y, horizontal σ_x (to the rise – dip), horizontal σ_z (along the strike), and according to generalizing indicator – stress intensity σ.

Before proceeding to the analysis of the stress component distribution, it is necessary to explain and substantiate the approach to this analysis in accordance with the specifics of the task set and the geomechanical model constructed.

Firstly, the upper C_8^b coal seam has already been almost mined out near the main working network. And if the 850 extraction site is completely mined out (or will be in the stage of mining), then the disturbances of the C_8^b seam bottom rocks will approach the bottom of the main workings by propagating the reverse trough of the mass shift at a certain angle (15-30°) to the vertical. Therefore, regarding disturbances and weakening of rocks in the parting, it is necessary to study them also in the C_8^b seam bottom, that is, to determine the depth of distribution of bearing pressure zones (ahead of the stoping face) and de-stressing zone (in the mined-out area) influenced by the stope operations at least in the 850 longwall face. Such a condition brings the model closer to the real state of parting texture transformations and is a factor in obtaining more reliable results in terms of its stability.

Secondly, of course, the main factor in the disturbance of the balanced state of the parting and the probable stability loss of its part are the stope operations in the 518 longwall face. Here, the transformations of the coal-overlaying formation texture in the C_5 seam with the appearance of classical problems are of great interest. These are uncontrolled collapse, hinged-block displacement, and smooth deflection of layers without loss of continuity [51]. Accordingly, it becomes necessary to determine the propagation distance of concentration zones (de-stressing) of SSS components into the C_5 seam roof, which cause disturbance of the rock layers and affect the parting stability.

Therefore, the geomechanical situation peculiarities, when mining the C_5 seam 518 extraction site, require the study of discontinuity and the development of weakening zones both in the C_8^b seam bottom and in the C_5 seam roof.

Usually, the most informative and visual SSS component is the vertical stress σ_y distribution curve, an example of which is shown in Figure 2a. First of all, it should be noted that the σ_y distribution parameters are fully consistent with the existing results of modeling the state of the coal-bearing stratum during the coal seam mining. More specifically, when mining the C_8^b coal seam, we are interested in the propagation of σ_y anomalies (concentration, de-stressing) in its bottom, which is part of a parting. Ahead of the 850 longwall face there is a frontal bearing pressure zone with the following parameters:

– definitely destructive concentration σ_y of the level:

$$K_y = \frac{\sigma_y}{\gamma H} = 2.5 - 3.0\,, \tag{3}$$

penetrates into the bottom to a depth of 8-9 m and causes weakening and stratification of the upper part of a parting;

– a slightly lower concentration of $K_y = 1.9$-2.1 also weakens the soft rocks of the C_8^b seam bottom, since they are mainly represented by weak moistened argillites, and the coal seams C_8^{b0}, C_7^{top} and C_7^b are ultra-thin and are not able to resist increased rock pressure; this area propagates to a depth of up to 17-19 m;

– a moderate concentration σ_y of $K_y = 1.5$-1.6 level reaches a depth of 25-28 m and intersects with stronger siltstones and argillites; some partial weakening and stratification is possible here.

From the point of view of the calculation reliability, we will assume with a certain margin that the loss of continuity and stability of the C_8^b seam bottom rocks occurs up to a depth of 30 m.

Next, the destressing zone σ_y, which is formed in the mined-out area behind the 850 longwall face, is studied. Here there is a stratification of rocks under the action of tensile σ_y stresses near the mined coal seam boundary with vertical displacement of the bottom rocks into the mined-out area. Tensile σ_y stresses penetrate into the C_8^b seam bottom to a relatively shallow depth of 3.7-4.0 m. But the most intense de-stressing of the $K_y = 0.02$-0.17 level is dangerous because any poorly predicted rock pressure manifestations unbalance a sufficiently large rock volume, and it begins to move towards the mined-out area with corresponding stratification and weakening. This phenomenon can lead to potential instability and hazards, highlighting the importance of accurate prediction and management of rock pressure to ensure the safety of the mined-out area.

(a) (b)

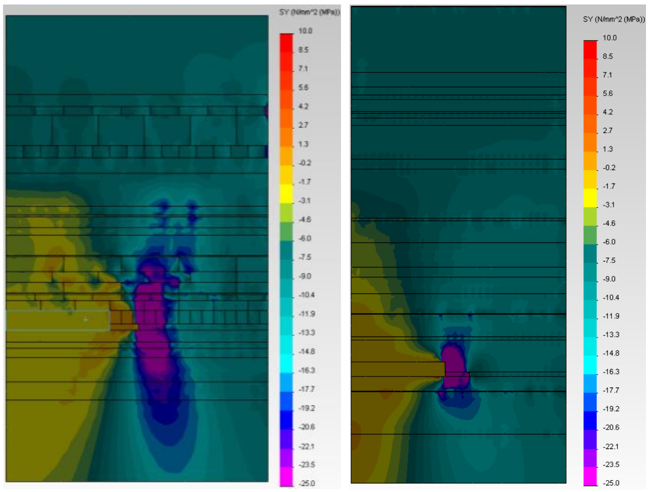

Figure 2. Curve of vertical stresses σ_y: (a) when mining the C_8^b seam 850 longwall face in the YZ section (along the 850 extraction site); (b) when mining the C_5 seam 518 longwall face in the YX section (along the 518 extraction site)

In addition, there is one factor – the action of horizontal stresses σ_x and σ_z, which reflect additional zones of tension and compression: tension intensifies rock stratification; compression concentrations – the lithotype destruction, since there are practically no vertical (restraining) stresses σ_y, and in any rock strength theory such a ratio of stress components is dangerous.

Therefore, the weakening of the bottom rocks in the de-stressing zone up to 20-23 m is quite probable; this is somewhat less than the weakening depth in the frontal bearing pressure zone, therefore, the depth of disturbances in the C_8^b seam bottom, 30 m is taken as the final indicator.

This conclusion is confirmed by the analysis of horizontal σ_x, σ_z stresses and stress σ intensity distribution, the results of which will be presented a little later, and now the main attention is paid to the disturbances of the C_5 seam roof rocks when mining the 518 longwall face. The curve of vertical stresses is shown in Figure 2b.

The frontal bearing pressure zone ahead of the longwall face has the following indicators:

– the rock-destroying vertical stress concentration of the K_y = 2.5-3.0 level propagates into the roof to a height of 6.5-7.0 m; here the rock destruction definitely occurs, because in absolute terms, the compressive stresses σ_y exceed the calculated strength of argillite and siltstone by 2.6-3.4 times;

– a somewhat lower concentration of the K_y = 1.9-2.1 level penetrates to a height of up to 9.0-11.5 m and also causes the weakening and destruction of argillite and siltstone rock layers;

– even higher, the concentration σ_y of the K_y = 1.6-1.8 level acts towards the roof, which is also destructive for the siltstone, and the sandstone is able to withstand such compressive stresses with some disturbances near the siltstone stratification; this zone propagates into the roof up to 14.0-17.5 m;

– further, the concentration of σ_y decreases when moving into the C_5 seam main roof, but local zones are possible where partial weakening of lithotypes occurs, especially slightly moistened argillite (between the C_6^{top} and C_6^b seams) at a distance of up to 31.2 m. These local zones are unlikely to be involved in the active displacement of the coal-overlaying formation and mostly do not lose stability. But with a certain margin to increase the calculation reliability, the height of the possible weakening zone of rocks influenced by stope operations in the 518 longwall face can be taken up to 35 m.

The de-stressing zone behind the 518 longwall face is characterized as follows:

– the maximum degree of de-stressing K_y = 0.02-0.17 propagates to a height of up to 27-28 m and, as noted earlier, this zone is potentially dangerous in terms of weakening the coal-overlaying formation;

– higher into the main roof, the vertical stresses σ_y increase quite quickly to the K_y = 0.31-0.60 level, and this zone can be considered quite stable with regard to the absence of weakening and stratification of the rocks in the C_5 seam main roof.

Summarizing the above stated, it is possible with a fairly high degree of probability to consider the stope operations influence in the 518 longwall face up to 35 m high as limited. Then the total influence on the parting state (from 850 and 518 longwall faces) is predicted for a distance of up to 65 m. Thus, 37 m of parting rocks remain stable.

The rest of the stress components basically confirm the given conclusion. As an example, the distribution of horizontal stresses σ_x in the *YX* plane is shown in Figure 3a. There is an intense bending of the main roof lithotypes near the C_5 seam and the main bottom lithotypes near the C_8^b seam, and inside the parting this bending slows down, which corresponds to the classical zone of "smooth bending of rock layers without discontinuity". Figure 3b shows the curve of the stress intensity σ in a certain area along the 518 extraction panel length. The weakening and destruction of the bottom rock layers near the C_8^b seam is also predicted here, while the middle part of the parting is in a stable state.

(a) (b)

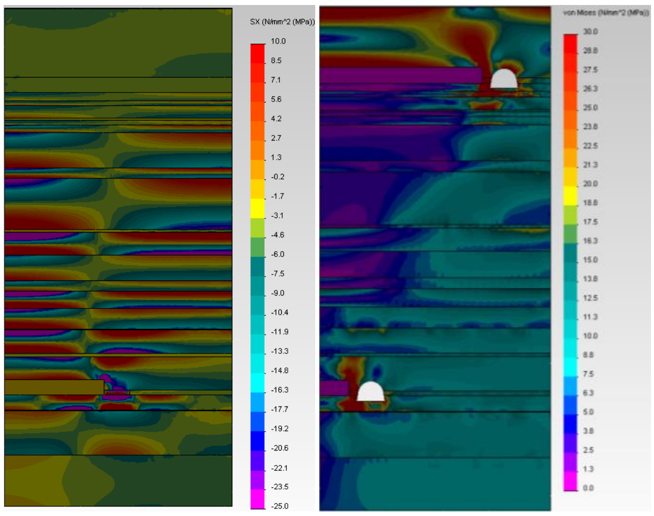

Figure 3. Curve of horizontal stresses σ_x: (a) when mining the C_5 seam 518 longwall face with already mined-out (in this area) 850 longwall face; (b) when mining the C_5 seam 518 extraction site with already mined-out extraction panel

Thus, summarizing the research results, it can be stated with confidence that the discontinuities of the parting lithotypes are limited (with a certain margin) at a distance of up to 65 m, and at the remaining 37 m, the rock layers are in a stable state. This leads to a conclusion that there is no stope operations influence in the 518 longwall face on the main working network stability in the C_8^b seam.

This conclusion is confirmed by a series of mine studies, fragments of which are shown in Figure 4, as well as the existing experience in studying the rock stability throughout the parting thickness [52], [53].

Figure 4. Fragments of the mine working state during mine studies

A series of multivariate computational experiments on the calculation of the stress-strain state of rocks, conducted using a new methodology reflecting the structural rock transformations, is compared with a complex of mine studies with constant monitoring of the mine working state. The data obtained provide an objective assessment of the degree of reliability of the conclusions drawn. Thus, the adequacy of the conducted research on the assessment of the safety degree of the main working network state during their mining has been proved.

4. Conclusions

The probable stability loss of the main working network in the C_8^b seam in the process of their undermining with stope operations in the C_5 seam is studied. For this purpose, the texture and mechanical properties of the parting rocks have been analyzed on the basis of geological information on a number of wells located near the C_8^b seam main workings, and the geomechanical parameters have been generalized throughout the entire parting thickness.

Instrumental observations of the main working network state give grounds to consider it mostly satisfactory, provided there is no planned stope operations influence in the lower C_5 coal seam.

To study the parting state, the parameters have been substantiated and a spatial geomechanical model has been contructed, which includes all the main elements reflecting the mining-technical situation.

The parting SSS analysis has proved that with a certain margin of calculation reliability, its weakening and stratification are predicted to be up to 30 m in the C_8^b seam bottom and up to 35 m in the C_5 seam roof. There are 37 m of solid rocks left, which ensures a stable state of the parting and the absence of the stope operations influence in the C_5 seam on the main workings network of the C_8^b seam.

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Оцінка геомеханічного стану мережі магістральних виробок при їх підробці в умовах слабометаморфізованих порід

Г. Симанович, М. Одновол, В. Яковенко, Р. Сачко, І. Шайхлісламова, Т. Решетілова, М. Стадничук

Мета. Геомеханічне обґрунтування та визначення параметрів стану міжпластя гірничо-геологічних та гірничотехнічних умов на базі аналізу для обґрунтування безпечних умов експлуатації мережі підроблюваних магістральних виробок.

Методика. Алгоритм вивчення стану мережі підроблюваних магістральних виробок, який включає: аналіз текстури і механічних властивостей порід міжпластя; шахтні інструментальні спостереження за проявами гірського тиску у магістральних виробках; моделювання стану міжпластя за допомогою методу скінченних елементів (МСЕ), розрахунок і аналіз його напружено-деформованого стану (НДС) з прогнозуванням ступеня впливу очисних робіт на можливі порушення вимог правил безпеки щодо експлуатації мережі магістральних виробок.

Результати. Проведено аналіз особливостей текстури і механічних властивостей літотипів навколо мережі магістральних виробок, міжпластя та зони майбутнього ведення очисних робіт по нижньому пласту. Досліджено теперішній стан магістральних виробок і разом з попереднім аналізом зроблено прогноз проявів гірського тиску з акцентом на ймовірний вплив очисних робіт по нижньому пласту. Для остаточного вирішення цього питання обґрунтовано параметри та створено геомеханічну модель поведінки міжпластя. Проведено розрахунок і аналіз НДС порід міжпластя, на базі яких сформовано висновок щодо можливості безпечної експлуатації мережі магістральних виробок.

Наукова новизна. Отримані нові знання з особливостей розподілу компонент НДС у міжпласті, що відрізняються урахуванням його великої потужності (в районі 100 м), але слабкими міцнісними властивостями усіх без винятку літотипів, які ще більше знижуються послаблюючими факторами тріщинуватості, шаруватості та зволоження від великої кількості вугільних пластів, що залягають по висоті міжпластя. Для вивчення стану міжпластя вперше обґрунтовано і побудовано просторову геомеханічну модель з урахуванням всіх елементів, що відображають гірничотехнічну ситуацію.

Практична значимість. На базі аналізу НДС міжпластя доведено існування його стійкої частини потужністю близько 37 м, яка забезпечує відсутність впливу очисних робіт по нижньому пласту на стан мережі магістральних виробок верхнього горизонту, тобто, обґрунтовані безпечні умови їх експлуатації. Проведені дослідження є базою для розробки рекомендацій для забезпечення безаварійної експлуатації.

Ключові слова: *гірський масив, міжпластя, виробка, підробка, моделювання*