

RESEARCH INTO ROCK PRESSURE MANIFESTATIONS IN INTERSTRATAL ROCKS DURING DESCENDING AND SIMULTANEOUS MINING OF C₉ AND C₁₀^{TOP} COAL SEAMS

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ДОСЛІДЖЕННЯ ПРОЯВІВ ГІРСЬКОГО ТИСКУ В ПОРОДАХ МІЖПЛАСТЯ ПРИ НИЗХІДНОМУ ТА ОДНОЧАСНОМУ ВІДПРАЦЮВАННІ ВУГІЛЬНИХ ПЛАСТІВ C₉ І C₁₀^B

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ABSTRACT

Purpose. To estimate the probability of interstratal rocks stability loss during simultaneous mining of two seams in series in the descending order.

Methods. Methods of a computing experiment and mine observations were used for conducting the research.

Findings. Recommendations for the improvement of 914 bolting system parameters of complex roadway for possibility of its reusing are developed.

Originality. Regularity of stress-strain state change of parting during simultaneous mining of coal seams with the purpose to reveal the constituent of rock pressure manifestations during the top seam mining is studied.

Practical implications. The received results can be generalized for the purpose of providing recommendations concerning bolting and supporting of mine workings during simultaneous mining of seams in series.

Keywords: coal seams, simultaneous mining, stress-strain state, parting, overworking

1. INTRODUCTION

One of the main distinctive features of thin coal seams mining in mines of Western Donbas in conditions of pillar excavation, high loading on longwall and retreat mining of deposits, is reuse of extraction mine workings. At the same time, length of extraction pillars and, therefore, the extent of local roadways constantly increase and steadily approach 3 km, which complicates their maintenance in satisfactory conditions during the entire period of pillar mining. In mines of the Western Donbass, coal strata are mostly mined in series of 2 and in the descending order. Moreover, because of the increased distance between the strata they cannot be referred to the category of contiguous seams. In this regard, authors of the work (Barabash, 2016), departing from experimental research

into the stress of rocks in initially overworked and subsequently underworked massif of parting during C₉ and C₈^{Low} seams mining, made the conclusion that in complicated mining-and-geological conditions of the Western Donbass – "each concrete situation requires assessment of probability of parting rocks stability loss for the descending order of joint mining of two adjacent seams in series". It is also necessary to consider the impact of rock pressure manifestations in mining of the top seam while calculating parameters of bolting and protection systems of overworking of the lower seam.

Therefore, the main purpose of this stage of research consists in studying regularities of rock massif stress change between C₁₀^{Top} and C₉ seams in the course of mining the overlying C₁₀^{Top} seam. This change is considered from the perspective of estimating its influence on

transformation of bolting system loading in 914th complex roadway with subsequent optimization of bolting and protection schemes parameters during reuse. As the mining-and-geological situation for supporting 914th complex roadway of C₉ seam changes along its length, the multi-variant research into changeability of stress-strain state (SSS) of the massif (between C₉ and C₁₀^{Top} seams) was done considering its structure and mechanical characteristics.

2. ESTIMATION OF MINING-AND-GEOLOGICAL CONDITIONS OF MINING OPERATIONS

The analysis of prognostic mining-and-geological section on 914th complex roadway has shown essential changes (along its length) of rock strata structure between C₉ and C₁₀^{Top} seams with lithotypes replacements for fluctuation of their thickness from 0 to 12.3 m (Fig. 1). Such variation of structure and properties of parting results in considerable variability of rock pressure manifestations along mine working length which should be taken into account when choosing parameters of 914th complex roadway supporting means.

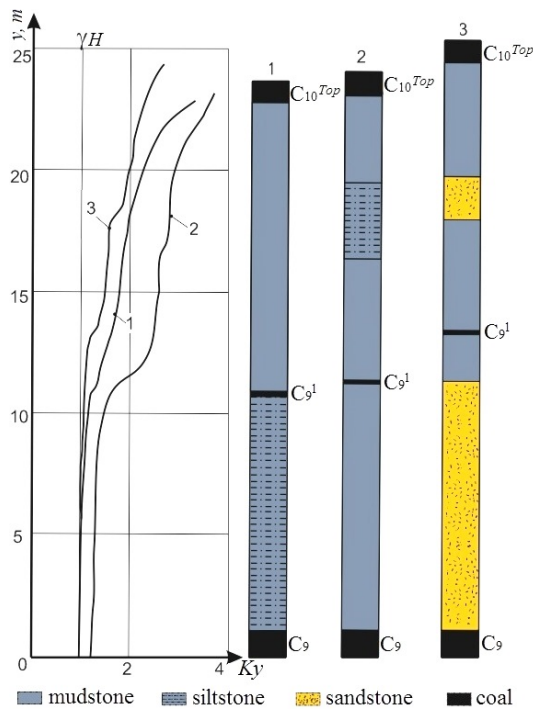


Figure 1. Changing of concentration coefficient K_y of vertical stresses along the parting thickness on significant sections of 914th complex roadway length: 1 – lower; 2 – middle; 3 – top sections

In the lower part of mine working length (section 1), the parting is composed by two thick rock seams of siltstone (to 11.3 m) and mudstone (to 12.3 m) that are divided by C₉¹ coal seam with thickness of 0.15–0.27 m. Siltstone is fine-grained, micaceous, horizontally-foliated due to existence of thin lenses of sandstone and has an average (for conditions of the Western Donbas) resistance to compression $\sigma_{comp} = 25$ MPa and to stretching $\sigma_s = 1.8$ MPa. Besides, it is rather steady in the natural wet state. Mudstone is wet, the texture is foliate. In the area of contact with the floor of C₁₀^{Top} coal seam with thickness

up to 0.5–0.7 m, it has lump texture and is very unstable; its resistance to compression is $\sigma_{comp} = 9–18$ MPa, to stretching $\sigma_s = 1.2$ MPa. It is liable to heaving and is generally considered as unstable. Coal shed is strong, viscous, striate-banded, wet, crumbling, having weak contacts with side rocks; $\sigma_{comp} = 30$ MPa; $\sigma_s = 1.6$ MPa. In view of contacts' weakness, it will divide parting into two parts under the influence of the increased rock pressure.

Section 2 in the middle stretch of 914th complex roadway is predicted to have lower stability in view of the following features of the parting. The main roof is comprised of thick mudstone (8.5–11.5 m) with lower resistance to compression I . Besides, this lithotype is liable to more intensive strength decrease under the impact of water saturation, and it is located between two water-conducting coal seams – C₉ and C₉¹. Mudstone of the lower strength ($\sigma_{comp} = 9–18$ MPa) is placed above C₉¹ seam. It is liable to weakening during moistening, as its rather small thickness (1.8–4.1 m) allows to saturate a considerable volume of the lithotype with moisture. Still bigger loss of strength of the same mudstone can be predicted in the floor of C₁₀^{Top} seam where its thickness is 2.2–3.6 m. Siltstone (2.6–2.9 m thick), micaceous and horizontally-layered, crumbling and unstable according to geological research, is placed between seams of possibly weakened mudstone. The above arguments allow to predict the most intensive rock pressure manifestations in this section of 914th complex roadway.

In the top part of 914th complex roadway extent (section 3), siltstone is replaced by rather thick (to 10.1 m) sandstone with resistance to compression $\sigma_{comp} = 30–60$ MPa, and resistance to stretching $\sigma_s = 1.6$ MPa. Sandstone is characterized as quartz, fine-grained on argillo-calcareous cement, strong, water-bearing, crumbling, with layered texture, heavy, letniform, hogbacked.

Mudstone with resistance to compression $\sigma_{comp} = 20$ MPa and thickness 2.0–6.1 m is placed between sandstone and inter-layer C₉¹. This value is most certain to sharply decrease in view of direct contact with water-bearing lithotypes. There are two layers of weaker mudstone ($\sigma_{comp} = 9–18$ MPa) 4.2–5.0 m thick, between C₉¹ and C₁₀^{Top} seams. Between these layers, there is sandstone ($\sigma_{comp} = 30–60$ MPa) with thickness 1.4–1.6 m. In general, despite the presence of partially moistened mudstones, the fact that there are sandstones (especially in the nearby roof of mine working) allows to predict decrease in intensity of rock pressure manifestations in section 3 of 914th complex roadway.

The allocated sections, in our opinion, most fully characterize variation of structure and properties of rock strata between C₉ and C₁₀^{Top} seams.

3. THE MAIN PART OF RESEARCH

3.1. Analysis of rock massif stress during C₁₀^{Top} seam mining

First of all, spatial sections of distribution fields of stresses vertical components σ_y of rock massif in the vicinity of 1014th longwall of C₁₀^{Top} seam are considered. In view of variability of structure and properties (water content, cracks content, rheology) of rock mass between C₉ and C₁₀^{Top} seams, several computing experiments for different mining-and-geological conditions of supporting

914th complex roadway corresponding to different sections of its length have been conducted. The diagram of vertical stresses distribution (Fig. 1) is of primary importance here as it allows to derive the depth of rock pressure anomalies influence in the floor of C₁₀^{Top} seam and extent of their effect on stress-strain state (SSS) change of C₉ seam roof rocks.

It is well-known that the most intensive rock pressure is formed in the front and on each side of the stopping face; therefore, the main attention is paid to the zones of front and side abutment pressure. In the end section of 1014th longwall, the front abutment pressure in the floor of C₁₀^{Top} seam has the known tendency to attenuation with depth, which is usually characterized by distribution of concentration coefficient K_y of vertical stresses σ_y :

$$K_y = \frac{\sigma_y}{\gamma H}, \quad (1)$$

where:

H – depth of mine operations;

γ – average weighted volume density of coal-overlying strata.

Weakening floor rocks concentration $K_y = 2.6 - 3.1$ extends into C₁₀^{Top} seams floor to the depth of 11.6 m and is localized around C₉¹ coal seam placement; violations of floor rocks of C₉ seam are not predicted for the depths bigger than this mark. Therefore, it is possible to assume that roof rocks of the seam stay integral to the height about 10 m by the factor of front abutment pressure impact in front of the 1014th longwall of C₁₀^{Top} seam. In section 2, parting concentration K_y value decreases with depth, and concentration σ_y is equal to only $K_y = 1.2 - 1.3$ around C₉ seam placement (Fig. 1, diagram 2). Such level of acting vertical stresses σ_y in comparison with strength characteristics of rocks of adjacent and main C₉ seam roof allowed to claim that rocks are not subjected to destruction. However, increased (by 20 – 30%) initial stress of C₉ seam roof rocks can cause intensification of rocks disturbance around 914th complex roadway during its mining.

The similar analysis of vertical stresses σ_y is made also for the zone of side abutment pressure in terms of 1014th longwall influence. The results of parting rocks stresses were very similar: depth of $K_y = 1.2 - 1.3$ concentrations distribution reaches 25.0 m in the floor of C₁₀^{Top} seam and affects C₉ coal seam. This conclusion is considered during modeling of stresses in nearby massif and bolting system of 914th complex roadway of C₉ seam.

In addition to the above mentioned, we observe the distribution σ_y at the end of 1014th longwall (Fig. 1, diagram 3) for the section of 914th complex roadway with sandstone bedding in the roof (section 3). Isolines σ_y in the C₁₀^{Top} seam floor testify that the initial condition of untouched massif ($\sigma_y = \gamma H$) is established at much smaller depth of about 14.0 – 16.0 m. That is, both frontal, and side abutment pressure caused by 1014th longwall do not reach C₉ seam, which is why it is possible to state that overworking does not affect the condition of rock massif around 914th complex roadway.

When the thick (to 11.3 m) siltstone with resistance to compression 25 MPa (section 1) is embedded in the main roof of C₉ seam, the depth of abutment pressure

penetration caused by 1014th longwall somewhat increases (to 18.0 – 19.0 m), but does not reach coal C₉ seam (Fig. 1, diagram 1).

The most problematic section 2 of 914th complex roadway extent with the initial geostatic pressure corrected by coefficient of concentration $K_y = 1.2 - 1.3$ is considered in the further research.

3.2. Analysis of rock massif stress during overworking of 914th complex roadway of C₉ seam

Distribution diagram of vertical stresses σ_y is given in Figure 2 and is characterized by the following features. The arch-shaped unloading zone is formed in the roof of 914th complex roadway, most of which can be informatively described as an indicator of the so-called depth of unloading that is equal to the relation $\sigma_y / \gamma H$ of the actual vertical stresses σ_y and initial geostatic pressure γH of the untouched massif. Assessment of rock pressure anomalies is made for the studied conditions of overworking, taking into account abutment pressure caused by 1014th longwall of C₁₀^{Top} seam and the value 1.25 γH substantiated earlier.

Unloading depth of 0.22 – 0.37 degree extends to the height of 6.8 m, embracing a considerable part of the main roof comprised by sandstone; the arch of this unloading extent takes up to 5.0 m in width. The arch of full rocks unloading ($\sigma_y \approx 0$) is 1.6 m high max and 2.3 m max wide and is characteristic for the most unstable volume of rocks whose weight is estimated at about 17 – 20% of the frame support bearing ability. The unloading zone of 0.22 – 0.37 situated above the area of unstable roof rocks does not participate in the loading on the bolting system, because $\sigma_y = 2.8 - 4.7$ MPa acting here is 10 times less on average than the resistance of sandstone to compression.

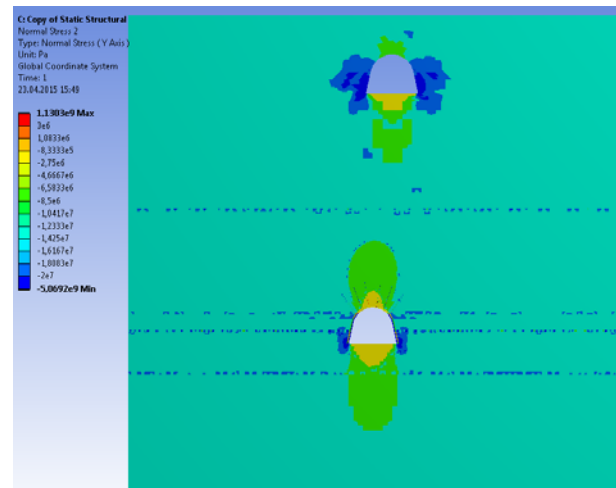


Figure 2. Diagram of vertical stresses σ_y in coal-bearing massif nearby 914th complex roadway of C₉ seam

There is one more feature of the vertical stresses distribution area caused by the influence of 914th complex roadway overworking and, more specifically, the zone of abutment pressure during C₁₀^{Top} seam mining. This feature consists in essential difference in the dimensions of anomalies areas of rock pressure in the vicinity of 914th complex roadway and overlying 1014th complex road-

way. As for the unloading zone in the roof of 1014th complex roadway, the distinctions are as follows:

- the area of full unloading is absent, that is, the action of stresses $\sigma_y \approx 0$ is not observed and, consequently, the arch of the limit state is not formed;

- the area with the unloading level of 0.22 – 0.37 is sharply reduced in height – 3.9 times, and in width – 1.8 times. The obtained data indicate that there is more considerable (in comparison with 914th complex roadway) effect of abutment pressure of 1014th longwall on roof rocks of 1014th complex roadway, because under the influence of vertical rock pressure concentration, squeezing forces σ_y , repeatedly limit the zone of partial unloading and completely liquidate the zone of full roof unloading. A different situation for the roof of 914th complex roadway is explained by the damping influence of a rather thick parting (24.1 m thick in the studied section) where action of abutment pressure on overlying C_{10}^{Top} coal seam is minimized. Therefore, diagram σ_y in the roof of 914th complex roadway is very similar to that in the absence of any overworking (Bondarenko, Kovalevska, Simanovich, & Chervatyuk, 2012).

In the floor of 914th complex roadway, areas of unloading (of the stated above levels) are more extensive than in the roof, which is also typical for conditions of Western Donbas, and the diagram is similar to conditions of working support beyond the zone of stoping operations influence. Thus for the unloading degree 0.22 – 0.37, the area extends to the depth of 9.0 m, while the width remains the same – 5.0 m. The area of full unloading, inducing the process of heaving, extends to the depth of 2.1 m, and width to 4.1 m, that is higher than the roof by 31% and 78% correspondingly. To compare the extent of abutment pressure influence around 1014th longwall, the dimensions of unloading areas in the floor of 1014th complex roadway are as follows:

- the depth of unloading reaches 7.1 m (21% less) for 0.22 – 0.37 level; while the width does not exceed 3.8 m (24% less);

- the depth of the full unloading area is 1.7 m (20% less), while the width remains the same.

These data also confirm limitation of unloading area in the floor of mine working due to the active influence of abutment pressure from 1014th longwall and essential reduction of influence when the parting is sufficiently thick.

Abutment pressure areas in the sides of mine workings (1014th and 914th complex roadways) have opposite tendencies of development, which is quite explainable, because abutment pressure of 1014 longwall is superimposed on abutment pressure of 1014th complex roadway. Only the abutment pressure from the mine working acts in 914th complex roadway, while the influence of overworking is insufficient. As a result, concentrations $\sigma_y = (1.51 - 1.67) \gamma H$ extend 2.2 times higher, and in width – to 3.2 times smaller distances for 914th complex roadway.

Thus, considering the factor of vertical stresses impact, it is possible to state that the influence of overworking on distribution σ_y around 914th complex roadway of C_9 seam is very weak.

3.3. Changes of rock massif stress during C_9 seam mining

Having studied the state of 914th complex roadway during its overworking by stoping operations on C_{10}^{Top} seam, we devoted the following stage of the research to the analysis of geomechanical processes of coal-overlying strata in the zone of stoping influence in C_9 seam. According to the existing research (Symanovych, Ganushevych, & Chervatyuk, 2010; Kovalevs'ka, Illiaшов, Fomychov, & Chervatyuk, 2012; Kovalevs'ka, Symanovych, & Fomychov, 2013; Rotkegel, Prusek, Kuziak, & Grodzicki, 2013), in conditions of the Western Donbas mines, the most active rock pressure manifestations are observed in the section located 20 – 40 m behind stoping face, and they gradually stabilize as the longwall retreats. This section is characterized by about 80 – 90% of vertical and horizontal migrations of the roadway boundary, and it is here that loading of its bolting and protection systems is finally formed. Therefore, to study the specified retreat of stoping face of 914th longwall, we developed a geomechanical model and conducted a computing experiment taking into account that C_{10}^{Top} seam mining was already completed. It allowed to prove that the most dangerous section (in our opinion) is located around 120 picket, that is the lower parts of extraction pillars of C_{10}^{Top} seam that are mined to the rise. The area around 120 picket is chosen because of a thick mudstone bedding in the roof and the floor of the seam with rather low strength characteristics, which allows to predict the increased intensity of rock pressure manifestations. Besides, 120 picket is placed in section 2 of untouched overworking influence (Fig. 1, diagram 2). The following zones of coal-overlying strata displacement are simulated to achieve the appropriate reliability of calculations (Chernyak & Yarynin, 1995; Bondarenko, Kovalevs'ka, & Fomychov, 2012) the zones of haphazard collapse, joint-block displacement and smooth deflection of layers without uniformity violation both in C_9 seam, and in a C_{10}^{Top} seam. We use the term “basic option” for the bolting and protection systems simulated according to the passport of 914th extraction section mining. The state of coal bearing massif is studied by vertical stresses σ_y whose diagram has the following characteristics (Fig. 3). A rather limited area of unloading in the form of arch formed in the roof of 914th complex roadway has the following parameters:

- for unloading $\sigma_y / \gamma H = 0.47 - 0.66$, the arch reaches 2.6 m in height and 2.9 m in width, insignificantly affecting the main roof rocks;

- deeper unloading $\sigma_y / \gamma H = 0.28 - 0.47$ is localized directly in the roof with height to 1.1 m and up to 2.3 m width;

- the area of full unloading ($\sigma_y \approx 0$) with the appearance of insignificant stretching is revealed only on the very roadway boundary with the depth of penetration into the massif 0.2 m.

These data confirm sufficient stability of roof rocks where no essential volumes of disturbed rocks are formed, which results in low loading of the frame beam. Therefore, there is no need to strengthen the beam by two wooden props for the frame yield keystones.

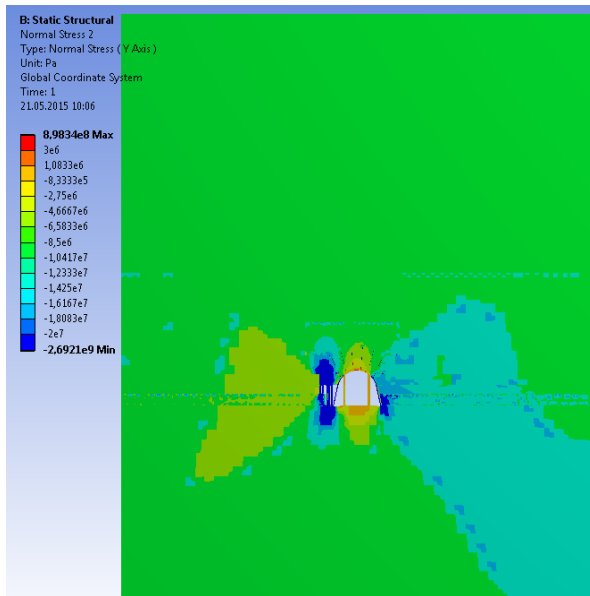


Figure 3. Diagram of vertical stresses distribution σ_y in coal-bearing massif around 914th complex roadway behind 914th longwall

The unloading area in the floor of the roadway has the form of the floor arch and extends to longer distances than in the roof:

- depth of unloading area development of the extent 0.47 – 0.66 reaches 4.1 m, and its width corresponds to the working width;
- the extent of unloading 0.28 – 0.47 penetrates to the depth of 2.0 m and to the width of 4.0 m;
- the area of full unloading reaches the depth of 1.0 m and width of 2.1 m. Here we can observe active stratification of adjacent floor rocks; however, the limited volume of these rocks allows to predict a moderate heaving up to 100 – 150 mm.

Distribution of vertical stresses in sides of 914th complex roadway is of great interest, especially where the zone of side abutment pressure is created on the side of its non-working board, and the area of high concentrations σ_y around the protection system placement – on the side of the working board. Behind this area is the goaf with the corresponding unloading zone. The areas described above deserve a particular attention for the following reasons. The previous calculations of SSS of the massif beyond the zone affected by stoping operations on C_9 seam, as well as the present computing experiment steadily show low loading of the frame beam, because the dome of extreme equilibrium, very limited in size, is formed in the roof. At the same time, frame props are subjected to high vertical loadings, which, from our perspective, can be explained by the following argumentation. The rocks of the main roof affected by stratification, subside on the underlying massif in the form of the plates of sufficient thickness and sizes along the run beyond the mine working width, which allows them to rest on rocks in the sides of mine working, including the protection system. Thickness of these plates (even if they are nothing more than an anchor system made of rock blocks) causes their deformation as a uniform load-bearing construction without notable deflections in the central part of their span where the frame beam is situated; therefore,

the plates of the main roof are poorly loading the beam, while the main efforts are focused on the support of plates on each side of the mine working, including frame props. The level of frame props loading depends on the degree of rocks integrity in the mine working sides (except protection system) which determines the level of resistance to the vertical rock pressure:

- given essential fracturing of side rocks, they are characterized by enhanced yielding and, during subsidence of rock plates, the main loading concentrates on frame props;
- side rocks, if their resistance is preserved at the sufficient level, take on themselves the most part of vertical pressure, thus unloading frame props.

Hence, the condition of rocks in sides of mine working is extremely important for preservation of its stability.

From the side of the untouched massif (left part in Fig. 3), the zone of side abutment pressure (from the retreat- ing 914th longwall) is characterized by such parameters:

- concentration of vertical stresses $\sigma_y / \gamma H = 1.23 - 1.62$ acts in a very large area, extending into the roof up to 9.2 m, into the floor for over 20.0 m, and along the strike – up to 14.0 m. If for roof rocks this concentration is not dangerous, the weak mudstone in the floor is characterized by the value of resistance to compression mostly lower than the acting vertical stresses;
- the main area of concentrations $\sigma_y / \gamma H = 1.62 - 1.81$ is located in the side of the mine working and extends to the height up to 5.1 m, along the strike – up to 4.0 m; though some areas of such concentration σ_y are present also in more remote sites of the massif; this concentration σ_y being still less than the resistance of mudstone of the main roof up to the height of C_9^1 inter-layer bedding;
- concentrations $\sigma_y / \gamma H > 2$ observed in the floor of the coal seam, penetrate to the depth of 2.4 m, extend to the width of 1.0 m and are unambiguously destructive.

According to the given results, it is possible to predict moderate side loading from the nearby roof rocks and active weakening of adjacent floor rocks and part of the main floor. Both predicted factors are dangerous from the point of view of frame support props stability. Side and oblique roof pressures combined with high loading by vertical impulse create prerequisites for their plastic deformation and bending by the height of the top roadway ripping. Intensive side pressure from the destroyed rocks of the floor along the depth of the lower roadway ripping creates a condition for bending of the props lower parts. Therefore, it is recommended to reinforce the noted areas of side rocks by resin-grouted roof bolts of standard length 2.4 m, which will allow to reduce the side pressure upon frame props. It is equally important to prevent excessive subsidence of rock plates in the roof due to the insufficient resistance of their support in the mine working side. Consolidation of the side rocks in the roof and floor of the coal seam ensures the ability of roof rock plates to bear the main vertical loading and protects the frame beam.

From the goaf side, mostly the protection system (rather than the adjoining caved roof rocks) acts as the main support for the roof rock plates. Here the unloaded zone (up to 15.5 m high, and to 12.5 m wide), which creates lower backup to overlying roof rocks, is formed. The main function of supporting roof rock plates is performed

by protection system, around which there appears concentration of compressive vertical stresses in the roof and floor of the coal seam:

– above the protection system: destroying stresses $\sigma_y > 20$ MPa extend into the roof up to 2.6 m and to the width of 1.9 m;

– under the protection system: stresses $\sigma_y > 13.5$ MPa ($\sigma_{comp} = 13.5$ MPa – compressive resistance of the seam floor mudstone) act at the depth of 5.3 m and width of 3.4 m.

The danger of weakening of the specified volumes of rocks is the following. Rocks of the adjacent roof above the protection system provoke increased lowering of roof rock plates during their weakening and, as a result, intensive loading of the frame support. For partial preservation of their integrity, it is recommended to strengthen them by resin-grouted roof anchors, which cross unstable volumes of rocks in the central part of area due to the change of coordinates of anchors position (approaching a brow of mined seam and reduction of the angle of their inclination to the horizontal). Pressing-in of the protection system elements happens during the weakening of floor rocks, which also provokes the increased lowering of roof rock plates with all the consequences coming with it. Therefore, it is also recommended to instal resin-grouted roof anchors along the depth of the lower roadway ripping in order to reinforce the mine working bankette. In addition, considerable volumes of weakening rocks below the protection system can provoke intensification of roadway floor heaving from the side of the goaf.

CONCLUSIONS

1. Estimation of mining-and-geological conditions of mining operations has allowed to single out three sections which fully characterize variation of the structure and mechanical properties of rock strata between C_9 and C_{10}^{Top} seams. Results of computing experiments for these sections have shown that during mining operations on C_{10}^{Top} seam, the most problems are connected with section 2 of the parting composed by the bedding of thick, but rather weak mudstone with high probability of water saturation. Here the weakening of floor rocks of C_{10}^{Top} seam extends up to 11.6 m, reaching the coal C_9^1 parting, and concentration of vertical rock pressure in the main roof of C_9 seam is 20 – 30% higher than that of initial condition of the untouched massif, which can promote intensification of rocks disturbance around 914th complex roadway during C_9 seam mining.

The condition of the lower segment of parting rocks in other sections of mine working allows to state that there is no influence of overworking on rock pressure manifestations around 914th complex roadway.

2. Analysis of vertical stresses distribution σ_y around overworked 914th complex roadway indicates negligible influence of rock pressure anomalies during mining of the over-laying C_{10}^{Top} seam. Considering key parameters of unloading areas in the roof and floor of the roadway, as well as the areas of abutment pressure in its sides, the diagram σ_y is very similar to that in the absence of any overworking. Hence we can conclude that in conditions of descending and simultaneous mining of C_{10}^{Top} and C_9 seams, the parting under study minimizes disturbance of rock pressure in the vicinity of 914th complex roadway beyond the zone affected by stoping operations on C_9 seam.

3. For the section of rock pressure manifestations stabilization, after 914th longwall passage, analysis of vertical stresses σ_y distribution in the massif around 914th complex roadway yielded the following:

– the limited volume of unstable rocks is formed in the roof rocks, which results in low loading of the frame beam;

– the combination of side (oblique) pressure in the side parts of the roof with high loading of frame props by vertical impulses creates prerequisites for their plastic bending along the height of roadway roof brushing;

– active weakening of rocks in the adjacent part of the main floor creates increased side pressure upon frame props and poses a danger of their plastic bending along the height of roadway floor brushing.

The revealed features of diagram σ_y have allowed to develop recommendations about changes in the parameters of bolting system of 914th complex roadway to ensure the possibility of its reuse.

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ABSTRACT (IN UKRAINIAN)

Мета. Оцінка ймовірності втрати стійкості порід міжпластя при одночасному відпрацюванні двох пластів у світі в низхідному порядку.

Методика. Для проведення досліджень використовувалися методи обчислювального експерименту та шахтні спостереження.

Результати. Розроблено рекомендації щодо вдосконалення параметрів кріпильної системи 914 збірної штреку для забезпечення можливості його повторного використання.

Наукова новизна. Вивчено закономірність зміни напружено-деформованого стану міжпластя при одночасному відпрацюванні вугільних пластів з метою виявлення складової проявів гірського тиску при відпрацюванні верхнього пласта.

Практична значимість. Отримані результати можуть бути узагальнені з метою видачі рекомендацій щодо кріплення й підтримки виробок при одночасному відпрацюванні пластів у світі.

Ключові слова: *вугільні пласти, одночасне відпрацювання, напружено-деформований стан, міжпластя, надробка*

ABSTRACT (IN RUSSIAN)

Цель. Оценка вероятности потери устойчивости пород междупластья при одновременной отработке двух пластов в свите в нисходящем порядке.

Методика. Для проведения исследований использовались методы вычислительного эксперимента и шахтные наблюдения.

Результаты. Разработаны рекомендации по совершенствованию параметров крепежной системы 914 сборного штрека для обеспечения возможности его повторного использования.

Научная новизна. Изучена закономерность изменения напряженно-деформированного состояния междупластья при одновременной отработке угольных пластов с целью выявления составляющей проявлений горного давления при отработке верхнего пласта.

Практическая значимость. Полученные результаты могут быть обобщены с целью выдачи рекомендаций по креплению и поддержанию выработок при одновременной отработке пластов в свите.

Ключевые слова: *угольные пласти, одновременная отработка, напряженно-деформированное состояние, междупластье, надробка*

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