Mining of Mineral Deposits
ISSN 2415-3443 (Online) | ISSN 2415-3435 (Print)
Journal homepage http://mining.in.ua
Volume 11 (2017), Issue 2, pp. 91-95

UDC 622.23
https://doi.org/10.15407/mining11.02.091

EFFECT OF ROCKS DISPLACEMENT ACTIVATION ON THE FORMATION OF THE SURFACE TROUGH DURING ANTHRACITE SEAMS EXTRACTION

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ВПЛИВ АКТИВІЗАЦІЇ ЗРУШЕННЯ ПОРІД НА ФОРМУВАННЯ МУЛЬД ЗЕМНОЇ ПОВЕРХНІ ПРИ ВІДПРАЦЮВАННІ АНТРАЦИТОВИХ ПЛАСТІВ

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ABSTRACT

Purpose. To define peculiarities related to the formation of the dynamic and stationary half-troughs under the influence of anthracite seam extraction by adjacent faces.

Methods. To establish the parameters of the surface displacement during the consecutive extraction of adjacent faces. Analysis of experimental data.

Findings. The effect of rocks displacement activation on the formation of the dynamic half-trough on the surface is established.

Originality. It is established that the length of the stationary half-troughs is almost functionally related to the total width of the goaf. The correlations between the stationary half-trough parameters and the degree of stoping development are determined.

Practical implications. The obtained results contribute to the improvement of measures for the rational protection of objects on the surface.

Keywords: *displacement, extraction, rock, activation, anthracite seams, displacement trough, double faces*

1. INTRODUCTION

The phenomenon of tapped rocks displacement activation was first described more than forty years ago by A.G. Akimov. He found that the nature of the displacement process, its parameters and deformations in the surface trough substantially change during the development of a multi-face seam compared to the displacement manifestations in processing of the isolated face. These changes are referred to as the general concept of the displacement activation. In developing several faces on the same seam, the surface displacement from several faces is composed of the displacements caused by the influence of separate stopes, with additional surface displacement above the boundaries of the adjacent faces (Akimov, Zemisev, & Katsnelson, 1970; Do, Wu, & Lin, 2017).

Dimensions of displacement troughs are characterized by lengths of two half-troughs, with significantly different formation processes. During the development of adjacent faces, one half-trough is formed above the discretely moving goaf boundary (dynamic trough), while the other is formed above the stationary goaf boundary with coal mass (stationary trough) (Teng, Xu, Xuan, & Wang, 2016; Wu, Zhang, Jeffrey, & Mills, 2016).

Defining the features of half-troughs displacement formation and their real dimensions in conditions of adjacent faces development is relevant in view of the absence of any recommendations on this matter in the normative document (HSTU, 2003; Hejmanowski, 2015; Seryakov, 2016).

The purpose of this paper is to identify the peculiarities of the dynamic and stationary half-troughs when developing adjacent faces and to study manifestations of activation processes of the tapped rocks displacement on the basis of experimental data.

2. THE MAIN PART OF THE ARTICLE

It is known (Akimov, Zemisev, & Katsnelson, 1970) that the harder the host rocks, the more intense their displacement activation. The rocks hosting anthracite seams are the hardest. For this reason, we used the results obtained during developing anthracite seam by adjacent faces at the depth of 660 – 720 m (Borzyh & Gorovoy, 1999). Two groups of stopes with four faces in each were developed on seam $K^{/}_{5}$. The length of the first group faces (L_f) was 190 – 200 m, while the length of the second group faces was 139 – 150 m.

In the beginning, two single faces 200 m and 193 m long of the first group were sequentially developed, and two single faces of 382 m total length were developed after that.

As a result of such anthracite seam mining sequence, the parameters of surface displacement troughs have been determined (Borzyh & Gorovoy, 1999) for the goafs 200 m, 393 m and 775 m wide (Fig. 1).

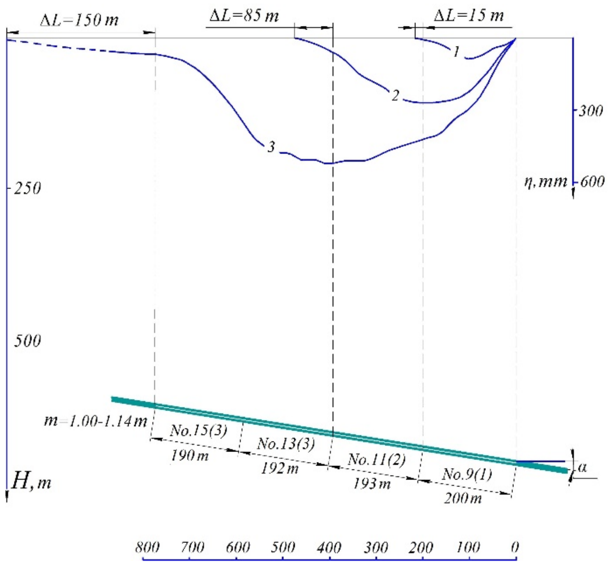

Figure 1. Graphs of surface subsidence after developing extraction pillars in P.L. Voikova mine (Borzyh & Gorovoy, 1999): No 9(1), No 11(2), No 13(3), No 15(3) – numbers of faces, the sequence of their mining and the corresponding surface displacement troughs; m – seam thickness, m; H – depth of stoping, m; α = 9 – seam inclination; η – subsidence of the surface, mm

In the other group, the seam was first mined by two double faces with a total length of 289 m. Then two more faces of 142 m and 146 m long were sequentially developed. During this process, the parameters of three surface displacement troughs were experimentally determined (Borzyh & Gorovoy, 1999) for the goafs 289 m, 431 m and 577 m wide respectively (Fig. 2).

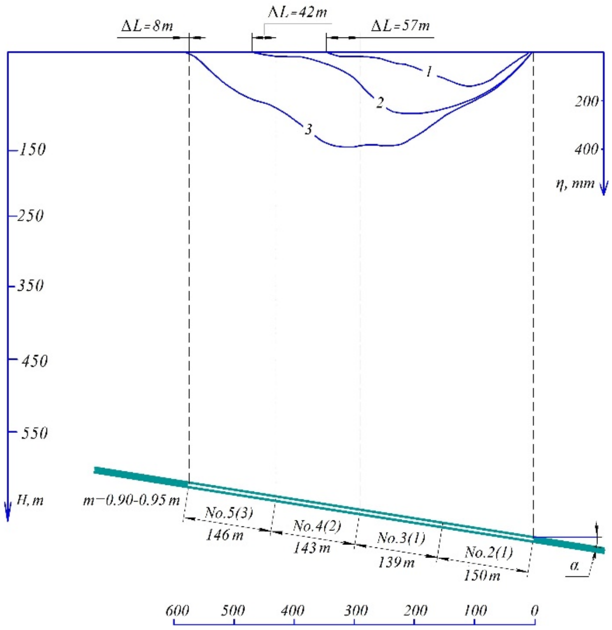

Figure 2. Graphs of surface subsidence after developing extraction pillars in P.L. Voikova mine (Borzyh & Gorovoy): No 2(1), No 3(1), No 4(2), No 5(3) – numbers of faces, the sequence of their mining and the corresponding surface displacement troughs; m – seam thickness, m; H – depth of stoping, m; α = 9 –seam inclination; η – subsidence of the surface, mm

The point of maximum subsidence which is determined for each trough (η_m) defines the boundary between the stationary and dynamic half-troughs. These data allowed to compute experimental lengths of the stationary (L_1^E) and dynamic (L_2^E) half-troughs, the maximum subsidence of the surface (η_m^E) and the values for projection of the dynamic half-trough (ΔL) part for the fixed goaf dimensions (Table 1). In all cases, the stationary half-trough length was determined by the projection of the goaf center on the one hand, and by the projection of the stationary goaf boundary with the coal mass – on the other.

The above considerations are confirmed by almost functional relation (correlation coefficient $r = 0.99$) between stationary half-troughs' lengths L_1^E and the total dimensions of operating faces' goafs (L_f) as well as extraction pillars developed earlier (B). The regression coefficient in the equation (1) is close to 0.5 (Fig. 3), which indicates that the point of maximum surface subsidence is located approximately above the middle of the goaf of $L_l + B$ width.

Table 1. Data about the face operation conditions and parameters of surface displacement troughs during mining of anthracite seam K'5

No	Face operation conditions			Experimental parameters of displacement troughs according to (Borzyh & Gorovoy, 1999)					The sequence of face development	Notes
	Face number	L_f, m	The width of idle blocks' goafs B, m	$L_l + B$, m	L_1^E, m	L_2^E, m	ΔL, m	η_m, mm		
1	9.00	200	0	200	100	110	15	90	1	1st group faces
2	11.00	193	200	393	195	270	85	300	2	
3	13.15	382	393	775	400	500	150	570	3	
4	2.30	289	0	289	99	240	57	136	1	2nd group faces
5	4.00	142	289	431	195	271	42	292	2	
6	5.00	146	431	577	302	279	8	393	3	

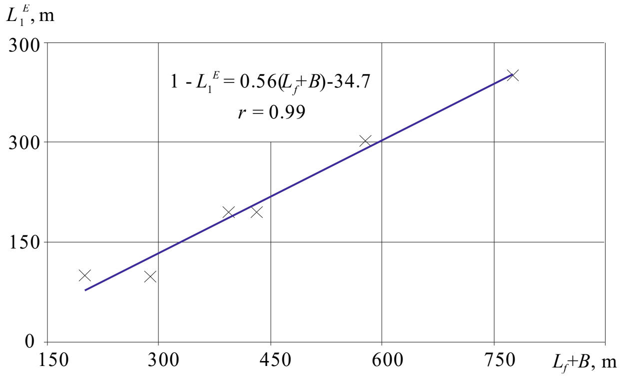

Figure 3. Dependence of the stationary half-troughs' length L_1^E from the total width of the goaf ($L_l + B$): ×– experimental data; 1 – averaging straight line; r = 0.99 – correlation coefficient

The dynamic half-trough was longer than the stationary one by the value *ΔL*, which, under the influence of rocks displacement activation, spread beyond the projection of goaf boundary with the coal mass.

Methodology of the work meant to establish the possible impact produced on the lengths L_2^E and ΔL of the operating faces (L_l) by the width of goafs of previously developed extraction pillars (*B*), the total dimensions of goafs of operating and finished faces ($L_l + B$), as well as the sequence of developing single and double faces. Analysis of the mentioned effect was made on the basis of the graphs (Fig. 4).

The parameters of dynamic half- troughs L_2^E and *ΔL* depended directly upon the length of the operating faces (L_l). The correlation coefficients (*r*) were 0.64 and 0.81 respectively (Fig. 4a).

The correlation between these parameters (L_2^E and *ΔL*) and the width of goafs (*B*) of previously developed extraction pillars was characterized by the correlation coefficients 0.71 and 0.27 respectively (Fig. 4b).

The most significant impact ($r = 0.93$) on the formation of the dynamic half-trough lengths (L_2^E) was made by the total dimensions of the operating faces (L_l) and goafs (*B*) of finished blocks (Fig. 4c). The relationship between the *ΔL* parameter and the total dimension ($L_l + B$) corresponds to $r = 0.61$. Here the tendency of increasing *ΔL* while operating double faces compared to working the seam by a single face was established. For example, after the development of the first group, double faces No 13 and No 15 of the total length of 382 m, *ΔL* parameter was more than 150 m, while during mining of single faces No 9 and No 11 with their total length of 393 m the parameter was not more than 85 m (Table 1). After the initial mining of group 2, double faces No 2 and No 3 of the total length of 289 m and $\Delta L = 57$ m, after sequential mining of two single faces No 4 and No 5 the parameter under research amounted 8 m only.

Such increased activation of the tapped rocks by double faces is evidently associated with the duration of these processes. It takes a certain period of time to proceed from mining a single face to putting a new one into operation. During this period, the intensity of the excavated rocks displacement is significantly reduced, which affects their activation when developing a single adjacent face.

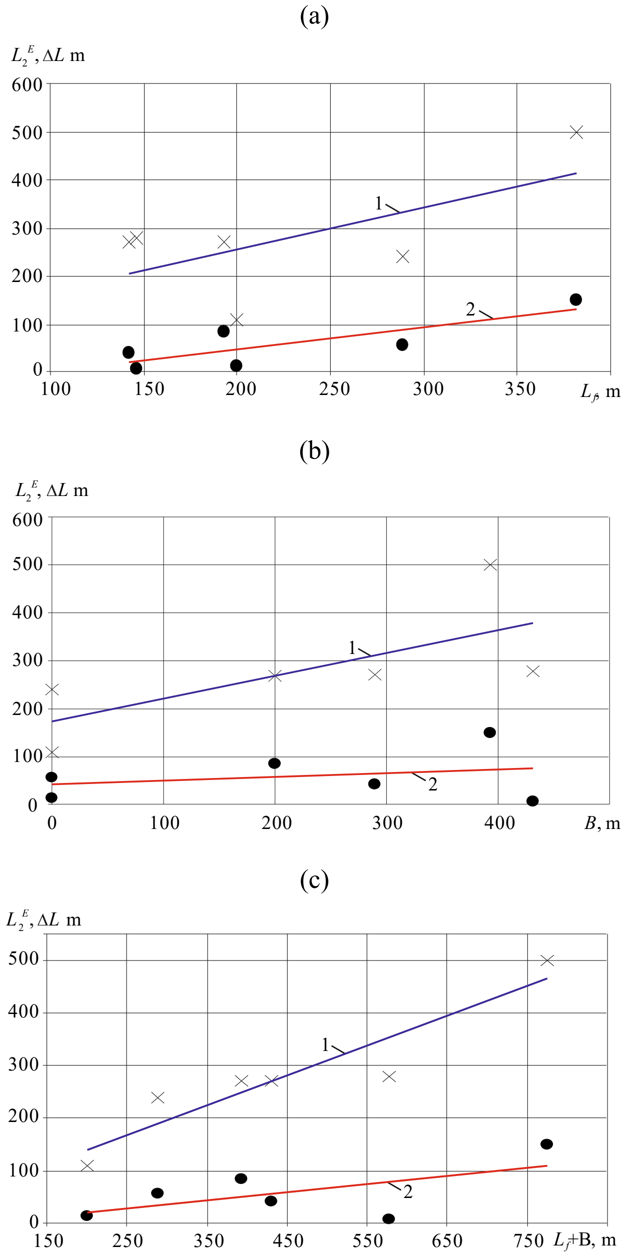

Figure 4. Relation of the dynamic half-trough length L_2^E and ΔL parameter of rocks displacement activation on the face length (a), the dimensions of the previously excavated faces' goafs (b) and the total width of the goaf (c): 1, 2 – averaging straight lines for L_2^E and ΔL, respectively; × – experimental data and L_2^E and ΔL according to (Borzyh & Gorovoy, 1999)

After developing the stope by the first of the double faces, the processes of excavated rocks displacement start to develop intensively. The movement of the other double face contributes to the further development and intensification of the processes of the tapped rocks displacement, which leads to the increase in *ΔL* parameter.

3. CONCLUSIONS

During the development of the anthracite flat-lying seam at medium depths (660 – 720 m), the maximum surface subsidence occurs above the goaf center.

The dimensions of the stationary half-trough is determined by half of the goaf length.

The dynamic trough length increases by ΔL under the influence of rocks displacement activation in comparison with the stationary trough. The value of this parameter depends on the size of the exploited and developed faces, as well as on the sequence of their mining. High ΔL values were observed during the development of double faces.

The length of the dynamic trough depends on the total dimensions of the exploited face and the goaf directly.

ACKNOWLEDGEMENTS

The article has been prepared within the framework of the state-financed programme No 208 "Developing a prognostic subsystem for controlling the dynamics of rock sites' methane content" (state registration No 0114U006105, 0114U004419), conducted by Donbass State Technical University.

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ABSTRACT (IN UKRAINIAN)

Мета. Встановити особливості формування динамічної та стаціонарної напівмульд під впливом відпрацювання антрацитового пласта суміжними лавами.

Методика. Встановлення параметрів зрушення земної поверхні при послідовному відпрацюванні суміжних лав. Аналіз отриманих експериментальних даних.

Результати. Встановлено вплив активізації зрушення підроблених порід на формування динамічної напівмульди на земній поверхні.

Наукова новизна. Встановлена практично функціональна залежність довжини стаціонарних напівмульд від загальної ширини виробленого простору. Визначено кореляційні зв'язки параметрів динамічних напівмульд від ступеня розвитку очисних робіт.

Практична значимість. Отримані результати сприятимуть удосконаленню заходів щодо раціонального захисту об'єктів на земній поверхні.

Ключові слова: *зрушення, підробка, порода, активізація, антрацитові пласти, мульда зрушення, спарені лави*

ABSTRACT (IN RUSSIAN)

Цель. Установить особенности формирования динамической и стационарной полумульд под влиянием отработки антрацитового пласта смежными лавами.

Методика. Установление параметров сдвижения земной поверхности при последовательной отработке смежных лав. Анализ полученных экспериментальных данных.

Результаты. Установлено влияние активизации сдвижения подработанных пород на формирование динамической полумульды на земной поверхности.

Научная новизна. Установлена практически функциональная зависимость длины стационарных полумульд от общей ширины выработанного пространства. Определены корреляционные связи параметров динамических полумульд от степени развития очистных работ.

Практическая значимость. Полученные результаты способствуют усовершенствованию мероприятий по рациональной защите объектов на земной поверхности.

Ключевые слова: *сдвижение, подработка, порода, активизация, антрацитовые пласты, мульда сдвижения, спаренные лавы*

ARTICLE INFO

Received: 30 January 2017
Accepted: 14 June 2017
Available online: 30 June 2017

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