

Research and Investigation of Factors Affecting the Behavior of Mine Pressure During Underground Coal Mining Operation

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Abstract

Coal is one of the essential energy sources, found abundantly within the earth's crust. Most coal mines worldwide, particularly in Afghanistan, are extracted using underground mining method. In order to extract coal mines through underground mining, well-reasoned and technical plans that answer all engineering and safety issues must be arranged. Extraction of coal layers underground causes various convulsions in the roof and floor of coal layers. The number of convulsions and its functioning depends on a series of different geological and technical factors. Therefore, in this research, the effective factors on how mine pressure works during underground coal mining have been researched and investigated using the library method, and later 16 effective factors have been selected for the occurrence of mine pressure. In order to determine the effect of these factors on how mine pressure works, a questionnaire was prepared and distributed to 32 university professors and professional engineers engaged in engineering in the mining sector. The results of these questionnaires show that all the selected factors have an important effect on the performance of mine pressure, including the type of roof rock, the direction of the sealing systems and the nature of the extraction pits have a great effect on the performance of the mine pressure during the underground extraction of coal mines.

Keywords: Mine pressure, Coal layers, Underground mining, Coal mines, Factors, Extraction

1. Introduction

This study addresses that there is a large amount of coal mine resources in the world, and a large amount of these reserves are extracted from the earth's crust every year. This topic is significant because most of the coal reserves in the world are extracted underground, and in Afghanistan, until now, all the coal mines that have been discovered are extracted by the underground mine method. Underground mining is a difficult process that can be done economically and safely by using advanced technology and professional human resources. During the extraction of coal layers, the impact of mine pressure in the extracted place or nearby is related to various factors; by analyzing and investigating these factors, the amount of mine pressure and how it affects coal deposits and siliques can be predicted. The mine flux that is created later from the digging of mines and extractive pits around them is related to various factors, among which factors such as strength, stability, sealing, humidity, geological characteristics of coal and roof rock, etc. However, there remains a gap in the literature regarding the fact that all bodies have a relatively stable balance in their state of establishment. Massive rock also has a stable balance, but during digging or creating holes (vacuities), it loses its balance and, as a result, produces a certain amount of potential energy. The generated energy causes the roof rock to fall. This phenomenon can take place in different forms and in different rocks. Recent developments in the field have shown that one of the important and fundamental issues in how to destroy and collapse the roof is the choice of parameters for coal mining systems. These parameters depend on a series of different geological and technical factors. In order to extract economically and safely coal mines, the parameters of extraction systems should be determined and selected considering the combined effect of natural and technical factors. Therefore, this paper aims to investigate all the influencing factors on how mine pressure works in the roof of coal mines, and later, its effects in controlling and destroying the roof of coal seams were analyzed, and its effect on mine pressure was ranked. One of the important issues in rock classification is the selection of parameters that have the most effect on engineering designs. Research has shown that none of the parameters or indicators alone can represent a joint stone. Different parameters have different effects and can determine the characteristics of rock in different geological conditions only if they are combined. The following three main parameters are necessary for the classification of rock: one parameter represents the characteristics of massive rock, second parameter represents the sealing, and the third parameter describes the conditions of the underground water (Jovanshir, Ataei, & Torabi, 2007).

1.1. Objective of the Research

The purpose of this research is to investigate the factors that have an effect on how mine pressure works during underground coal mining.

2. Research Methodology

This study employs the library method approach to the mechanics of rock; the physical and mechanical properties of mineral rock and the effects of mine pressures during excavation have been comprehensively investigated. After analyzing and examining the influencing factors in how mine pressure works, those factors that have a major and important effect on mine pressure have been selected. Data was collected through a questionnaire prepared to determine the impact of various geological and technical factors. In this questionnaire, there are 16 questions about the effective factors in the operation of mine pressures during the underground mining of coal mines. The statistical population in this research consists of mining engineers and university professors in the country who are engaged in scientific and educational activities in the fields of mining and mineral exploration. To this end, the questionnaire was distributed to professors of six universities in the country and four mining companies that extract coal through underground mining methods. It is worth mentioning that this research took approximately two months, and the questionnaire was prepared using Google Forms and then sent to eligible individuals for completion. After a one-month waiting period, around 32 individuals responded to the questionnaire. By using this method, the study aims to investigate Factors Affecting the Behavior of Mine Pressure During Underground Coal Mining Operation.

3. Literature Review

Previous studies have shown that digging the coal layer, the massive convulsive state of the mine rock (floor and roof) around the mining pits is changed. The massif of the roof rock has been completely destroyed, the seams have been created in the form of sheets, and finally, the rock has been increased in the place near the excavation site. The destruction of idle rock in the main roof has been done, which has a significant contribution to the emergence of mine pressure in the area near the mining pit and the place where it was mined. In the case of the presence of soft rock, the destruction of the dome like the roof is mostly done, and in the case of the presence of very strong rock in the roof, the plates and blocks of rock are separated from the roof and hang on top of the reinforcements. The low thickness of the direct roof and the strong rock of the basic roof allow it to sit perpendicular to the seams created in the sheets, and if the rocks are closer together, it causes consolidation.

According to Mir Fakhreddin (2014), the stability of mine rock is more related to their natural sealing. According to the origin, the seams are divided into internal ones, which are formed as a result of contraction factors, and external seams, which are formed as a result of tectonic processes. Research by Mark and Gadeh (2008) indicates that the roof rock of coal seams is subjected to vertical and horizontal tension. Vertical convulsions occur as a result of the pressure of the upper stone layers that are above the coal layers. Horizontal convulsions are caused by the effect of tectonic forces, which in most cases have a greater impact than vertical convulsions and cause the destruction of roof rock along their classification. The dimensions of the impact of the dangerous zone of underground excavations, the amount and characteristic of the deformation, as well as the durability of the movement of rock and the settlement of the earth's surface, are related to a number of different factors, which are: the size of the space under extraction is the geological conditions, i.e., the characteristics of the periodicity of the composition of the building and the properties of the rock, the technical conditions of the mine (speed of digging underground excavations, the size of the extracted space, maintenance methods, and the nature of roof reinforcements), etc. (Piridelski & Prihodchinko, 2014).

To measure the resistance properties of rock, it is considered necessary to perform laboratory tests to determine the mechanical properties of mine rock. The administration of excavations and extracted spaces is considered one of the important and key issues during the extraction of coal mines in an underground way. To determine normal sealing parameters, a three-axis compressive strength test is performed according to the Hook-Brown method. The mechanical parameters of rock and coal are included in the table (1) (Abolghasmifar & others, 2018, page 21).

Table 1: Mechanical parameters of rock and coal (Abolghasmifar & others, 2018, page 21)

No.	Mechanical Properties	Type of Rock	
		Sandstone	Coal
1	Specific Weight (Kg/m ³)	2670	1600
2	Bulk Modulus (GPa)	5.25	1.1
3	Shear Modulus (GPa)	2.7	0.7
4	Uniaxial Compressive Strength (MPa)	48.6	-
5	Young's Modulus (GPa)	6.9	-
6	Angle of Friction (°)	32.6	35

7	Cohesion (MPa)	1.3	1.13
8	Tensile Strength (MPa)	0.18	0.01

Today, the underground mining of coal mines is more widespread in the way of long excavation site (lava). In this way, a very important and fundamental issue is the proper control and destruction of the roof stone layers of the coal layers. Despite extensive research on this topic, one of the major risks during underground coal mining is the sudden collapse of the roof of mining pits. In order to reduce the possibility of sudden collapse of the roof, detailed engineering studies should be done to evaluate the roofs and rank the risks related to different geological and mine conditions. On this basis, providing different classifications for the roof of the layers during the extraction of coal mines in the long extraction zones is considered an important and key issue. Among the effective parameters on the performance of the roof of coal seams are the uniaxial compressive strength, tensile strength, sensitivity to moisture, thickness of the floors, the overlap of the roof stone seams, the strength and distance between the roof stone seaming systems, the angle between the extension of the roof stone seam, and the length. Extractive excavation sites and others are mentioned. (Mikael and others, 2018, page 11).

4. Research Findings

The research indicates that mine pressure is the occurrence of destructive forces in the area of mine excavations and mining wastes. There is no theory that can determine mine pressure in a complementary and accurate way. According to the position of the stone layers and the cross-section of the beds, the mine pressure is divided into two groups: 1- mine pressure corresponding (in horizontal layers) and 2- incongruent mine pressure (in inclined layers). The mine pressure in the undegraded massif is consistent with the horizontal surface, so if any mine pit has not been dug in the said massif, the mine pressure in that massif is investigated only by considering the gravitational forces. Factors that have an effect on the mine pressure include the depth of the extraction pits from the earth's surface, the physical and mechanical properties of the rock, the nature and elements of the location of the adjacent stone layers, tectonic forces, the order of extraction, the shape of the excavations, and their mutual position (Mir Fakhreddin, 1392, p. 2). Among the technical factors influencing the functioning of the convulsions and mine pressures of rocks adjacent to coal layers, we can mention the sizes of lava (extractive slag), the nature of consolidations, the density of consolidations, the experiences of workers who are engaged in the implementation of tasks in the extractive slags, etc. Geological (natural) effective factors include

sealing, rock water retention, rock stability, the nature of adjacent rocks and their characteristics, the thickness of coal layers, the existence of geological fractures, etc. And the study is placed:

Composition and geological structure of rocks

The roof rock of coal seams may have different mechanical properties that affect the resistance against the applied pressure. Soft rocks fail quickly, while hard rocks like igneous rocks are more stable.

Mine depth

The depth of the mine is considered an important and key factor in the operation of mine pressure, which increases with the increase of the depth of the mine. Coal mines that are located deeper in the earth's crust have a higher probability of roof instability. Therefore, modern and advanced methods must be used to extract such mines.

Extraction system

The extraction system is also a very important and fundamental factor during the maintenance and destruction of the roof of coal mines. For example, in the mining system with short shafts (cell extraction system), a special method may be used to control the roof, but this roof control method may not be used in the mining system with long shafts (lava). As in the extraction system with long shafts, the roof is controlled by mechanized reinforcements, but in the extraction system with short shafts, the coal roof is maintained by intercellular sieves. Lately, coal mining is done more with long pits (lava). Forecasting the state of the roof and its ability to destroy can help in performing safe and economical coal mining operations in the way of long tailings. The results of research on accidents in coal mines show that roof collapse is one of the dangers that workers face in coal mining pits (Mark & Molinda, 2005).

The formation and characteristics of stone seams

in rock mechanics, failure has different concepts, but its main concept can be defined as follows: failure is a process that changes the state of an object from one state to another. In other words, it is the failure of the process, as a result of which the state of the object changes. If the object changes from elastic to plastic or vice versa, failure has occurred (Shahriar, 2010).

Mine rocks are classified according to their sealing ability as follows (Mir Fakhreddin, 2014): 1- Seamless rock; 2- With low seams: this type of stone has a system of seams; the distance between these seams is more than 1 meter. 3: With medium seams: this type of stone has two systems of seams, the distance between which is more than 1 meter. 4: With a lot of seams: this type of stone

has several systems of seams; the distance between them is up to 0.5 meters. 5: With a lot of seams: this type of stone also has several systems of seams, but the distance between the seams is 0.2 meters.

The stability of mine rock

The property of mine rock to maintain its stability when mining is carried out on a bare surface is called the stability of mine rock. According to their durability, mine rock is classified as follows (Mir Fakhreddin, 2014):

- 1- unstable: the exposed surface does not maintain its stability without consolidation and is destroyed due to the progress of the excavation site.
- 2- With insignificant stability: near the excavation site with a width of up to 1 meter, it maintains its stability during 1-3 hours.
- 3- With medium stability: near the excavation site with a width of up to 2 meters, it looks its stability up to one day and night.
- 4- Stable: Near the excavation site, with a width of up to 12 meters, it is stable for up to 2 days.
- 5- Very stable: it has a long-lasting stability near the excavation site with a width of 2-6 meters.

Compressive and tensile strength of mine rock

The compressive and tensile strength of rock is one of the key factors in determining the stability of the roof of coal seams. Rocks that have high compressive and tensile strength are more resistant to the convulsions of the upper floors. But rocks with low resistance are more prone to failure and collapse. Uniaxial compressive strength is more important in the process of destruction of roof rock of coal seams than other characteristics of rock, which are followed by the thickness of roof stone layers and the number of seam systems of roof rock directly (Mohammadi & others, 2018). In the table below, a questionnaire has been arranged to determine the impact of various factors on the state of the roof of coal seams. This questionnaire has been distributed to 32 experts and scientific staff members in the fields of mining and mining exploration. In order to determine the importance and score of the above factors, the questionnaire was arranged according to table (2), and 32 scientific staff members and engineers who are engaged in teaching, research, and implementation of mining projects in the field of mining were asked for their opinions. After receiving the answers to the questions, the impact of various geological and technical factors has been received quantitatively. The results obtained from the questionnaires are included in Table 3.

Table 3: The results obtained from the questionnaires

No	Geological and Technical Factors Affecting the Performance of Mining Pressure in the Roof of Coal Mines	Impact Level of Factors				
		Very high	High	Medium	Low	Very low
1	Nature of the mine rocks	16	12	4	0	0
2	Stability of the rocks	8	14	8	1	1
3	Fracturing	12	16	4	0	0
4	Width of the fractures	12	6	8	6	0
5	Number of fracture systems	8	12	10	1	1
6	Direction of the fracture systems	2	22	4	2	2
7	Uniaxial compressive strength of the rocks	4	16	6	4	2
8	Sensitivity of the rocks to moisture	8	8	16	0	0
9	Effect of weathering	8	8	6	10	0
10	Impact of groundwater	12	14	4	0	2
11	Thickness of the roof rock layers	14	8	8	2	0
12	Inclination of the coal layers	10	10	12	0	0
13	Thickness of the coal seams	14	8	6	4	0
14	Width of the area near the extraction	8	10	8	6	0
15	Nature of the extraction methods (long wall, room-and-pillar)	10	18	4	0	0
16	Method of coal mining	10	10	8	4	0

The impact of the mentioned factors can be seen in the diagram shown in figure (1).

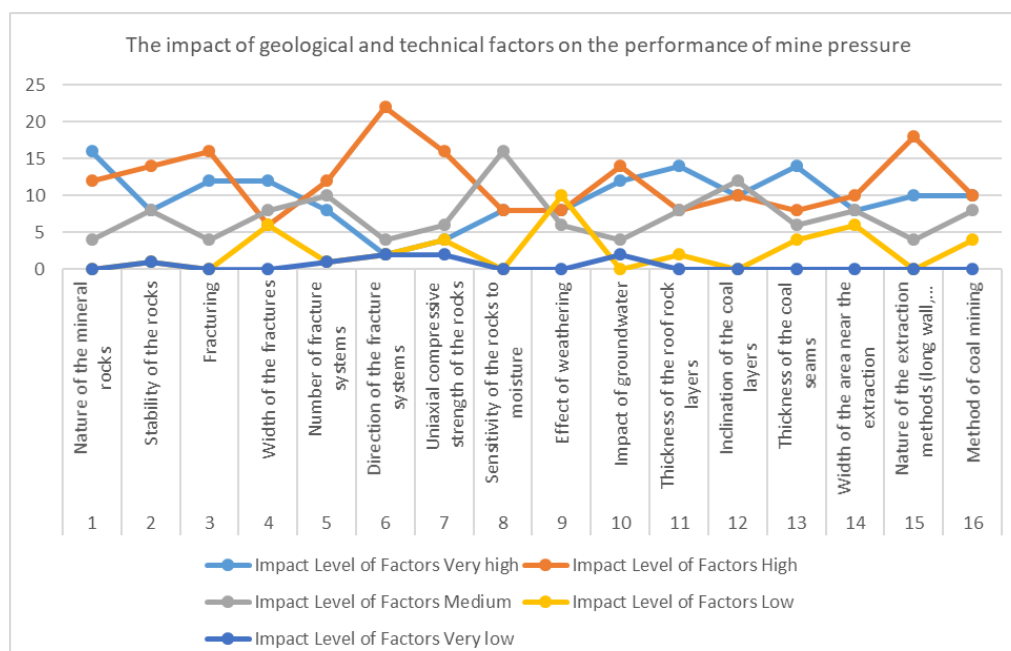


Figure 1: Diagram of the effect of various geological and technical factors on mine pressure in coal seams

5. Conclusion and Recommendations

in summary, this paper has shown that different geological and technical factors have different effects on the way mine pressure works during coal mining. The most effective factors in this part are the nature of the roof rock, the thickness of the coal layers and adjacent rock, the sealing and the direction of the sealing systems, and the nature of the extraction pits. With the increase in sealing, the possibility of destroying the coal roof increases compared to rock with low sealing. The extraction system is also considered a very important technical factor in the operation of the mine pressure of coal mines. In extraction systems with long shafts, the effects of convulsions in the roof are greater than in extraction systems with short shafts. The main findings of this research are that the geological and technical factors play an important and fundamental role in the way the mine pressure of the coal layers works, including the nature of the rock, the direction of the sealing system, and the nature of the extractives, which have a great impact on how it works. Mine pressure in coal mines. Sensitivity to humidity and the number of sealing systems have a moderate effect. Considering the results obtained above, the following suggestions are also raised: the occurrence of mine pressure and its sphere of action during underground mining of coal mines is a very closed and complex issue, and its control is considered one of the basic engineering measures. Therefore, in order to control the mine pressures, the geological characteristics of the rock adjacent to the coal layers, especially the roof rock, should be investigated in a complementary way. While studying and examining the nearby rock, geological characteristics such as the nature of the rock, their structure and texture, the thickness of the stone layers, the seaming and the direction of the joint systems, the humidity and the amount of underground water, etc., must be accurately determined. Technical factors should be selected considering geological factors in order to respond to high technical, economic, and safety indicators. If the rock of the roof tends to be destroyed more, in this case, extraction systems with long shafts should not be used, because in this case, the expenses in the part of consolidation and control of the roof will increase. But this issue should be examined and scientifically reasoned in terms of coal waste in siliks when using Ishqara systems with short straws.

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