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Studies of methane inflow from longwall floor into the mine atmosphere

Alexander Kobylkin[1], *Sergey* Kubrin[1], *Dmitry* Meshcheryakov[1], *Evgeny* Pozdeev[2], and *Iosif* Zakorshmennyi[1]

[1]Institute of Comprehensive Exploitation of Mineral Resources Russian Academy of Sciences, Moscow, 111020, Russia
[2]Digital Technologies and Platforms, Moscow, 115054, Russia

Abstract. The results of studies assessing methane inflow from longwall floor are presented. Based on mine observation data, the facts of an increase in local gas release from the carbon massif caused by an increase in the reservoir properties of rocks have been confirmed. A conclusion is made about the random nature of the spatial distribution of local sources of methane emissions in the lava. Measurements of methane content near a local gas source showed a decrease in its concentration with increasing measurement altitude. An assumption has been made about the connection between this reduction in gas pollution and the high speed of air movement near the soil. A fresh stream of air dilutes methane directly at the point of its release, and therefore, it is difficult to obtain data on the contribution of this source of methane inflow to the gas balance of the excavation site. The task has been set to assess the flow of methane from its local sources. A prototype of a device for measuring the flow of gas released from local sources is presented. The need for chemical analysis of samples of released gases is shown.

1 Introduction

The release of methane from longwall floor through cracks is a common phenomenon [1, 2]. It can be in the nature of both "sudden methane breakthroughs" into the mine workings and local emissions. To describe the ongoing processes, the mechanisms of sudden "rock destruction" are considered, cases of such destruction and gas releases are given, on the basis of which classifications of gas-dynamic phenomena are developed, however, the local releases we are considering require additional classification. Recording and analyzing locations of local methane emissions can help identify sudden outbursts of coal and gas. The methane problem can be solved by the correct choice of ventilation scheme for the excavation ventilation area [3, 4], however, local methane inflow from the soil, being variable in nature, introduces uncertainty into these calculations, which can lead to exceeding the permissible methane concentration. Today, in many countries, studies of gas movement in rocks are being carried out [5, 6], the equations obtained in the framework of these works describe the transport of gas through cracks, but they require clarification. Also, these studies emphasize the advance design of ventilation taking into account methane emissions from cracks.

Local gas release from the soil is usually associated with the formation of cracks in the longwall floor and the presence of a satellite formation, which is a methane reservoir [1, 2]. The presence of zones of increased fracturing, responsible for an increase in the permeability of the massif [7 - 9], causes a significant increase in deformations of the excavation contour [10], caused by the action of tangential forces.

Degassing measures also affect the unloading and loading of the rock mass, changing its filtration properties [8], which prevents the release of gas and contributes to its redistribution in the rock mass. This phenomenon may contribute to the formation of local sources of methane inflow in the lava. The degree of destruction of rocks will be greater, the higher the stress values and the lower their strength [11]. The combination of these processes and characteristics of rocks leads to the appearance of local sources of methane inflow in the lava soil.

The main sources of methane inflow into the longwall are: the face chest, mined-out space and broken coal [12 – 15]. Typically, the release of methane from the longwall floor does not significantly increase the gas balance of the excavation site. However, the presence of satellite layers in the immediate vicinity and connections in the form of cracks with lava can lead to a significant release of methane [1, 2]. Which in turn will introduce a significant source of gas emissions into the gas balance of the excavation site. With a risk-based approach to assessing aerological risks [13], local sources of methane emissions will affect the “degree of vulnerability of the ventilation scheme” of the excavation site. Methane may also enter the goaf, a volume filled with methane, from local sources.

An increase in methane concentration can lead to a stop in coal production, which leads to losses for mining enterprises [15]. Safety in terms of the gas factor also decreases and the risk of an accident increases. Thus, research into the release of methane from local sources into the mine lava atmosphere is an urgent task, the solution of which will increase coal production and improve safety in mines.

2 Materials and methods

As part of the study of the mechanism of methane inflow from longwall floor into the mine atmosphere, mine research was carried out. The lava of the Kuzbass mine was chosen as the object of study. In the lava, studies were carried out of the processes occurring during the local release of methane through the soil (Figure 1a). Methane emissions were found along the length of the lava, which can be seen both visually and audibly (Figure 1b).

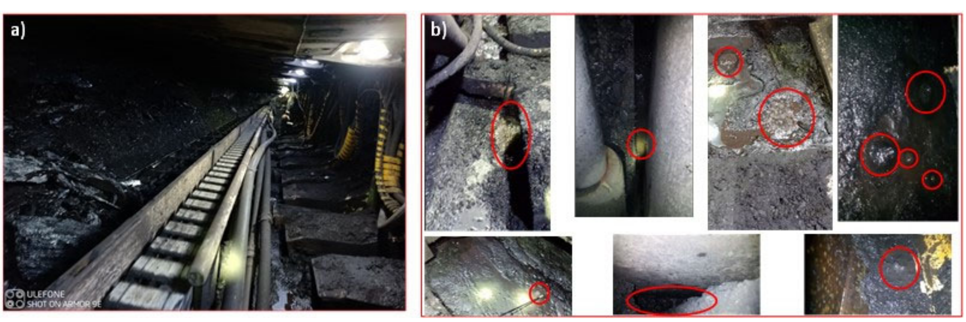

Fig. 1. Photo: a) measurement of methane concentration and air velocity in the longwall, b) methane inflow from the longwall floor.

The source of gas is the overworked "Intermediate" seam, located 13-17 meters from the mined seam. Soil rocks are represented by weak carbonaceous mudstones, siltstones and finegrained sandstone. Stress in these rocks led to the formation of cracks through which methane enters the lava.

As part of the research, air-gas surveys were carried out, and data on gas surveys in the lava were collected. Based on the analysis of materials from gas surveys of lava over a period of one month, a diagram was constructed indicating the points of methane inflow through the lava soil. The results are presented graphically (Figure 2).

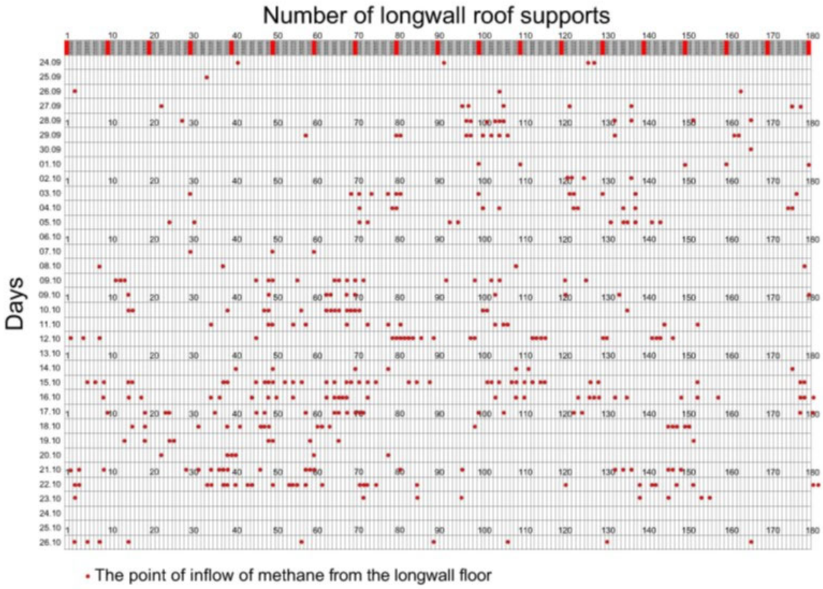

Fig. 2. Schematic showing the points of methane inflow from the longwall floor.

Figure 2 shows that the places of local methane releases are grouped together, which indicates the release of gas in weakened areas where fracturing is highly developed. Gas outlets are located mainly in the center of the lava, but they can also be found near the drifts. The question of the patterns of location of local segregations in the lava along its length requires additional research.

Having analyzed the gas survey data, we can conclude that the average concentration of methane in the longwall tends to increase from 0% at the support section No. 180 (entrance of the fresh jet into the longwall) to 0.6% at the support section No. 1 (output of the outgoing jet from lava). Which corresponds to the general idea of gas release processes in lava. It is worth noting that the measurements were carried out during a repair shift, which affected the measurement results. During the mining shift, the methane concentration would have been higher, and the dependence of the methane concentration along the length of the longwall would have had a different form. Broken coal and the freshly exposed surface of the coal seam would make a significant contribution to methane release. However, the approach used makes it possible to estimate the methane flow from the soil and its contribution to the overall gas balance with less errors.

A large number of local sources of methane inflow (up to 38 places) indicates the possibility of a significant influence of this source on the gas balance of the lava. Detection of local methane emissions during a repair shift may indicate their duration (under certain conditions, quite a long time). To quantify the released gas, it is necessary to measure the methane flow rate from local emissions.

Methane concentrations were also measured at the places where it was released, with the speed of air movement recorded at these points, to understand the process of diluting the gas with a fresh stream of air. The measurements were carried out using two portable gas analyzers “Sputnik 1M” CH4, % and two devices for monitoring air speed “APR-2”, m/s. The data of the measurements taken are given in Table 1.

Table 1. Measurement data of methane concentration and air velocity.

Support section no.	**Methane concentration, %, Sputnik 1m No. 433, soil**	**Methane concentration, %, Sputnik 1m No. 484, soil**	**Air movement speed, m/s, APR_2 No. 29, soil**	**Air movement speed, m/s, APR_2 No. 25, soil**	**Methane concentration, %, Satellite 1m No. 433, 60 cm from the soil***	**Methane concentration, %, Satellite 1m No. 484, 60 cm from the soil***	**Air movement speed, m/s, APR2 No. 29, 60 cm from the soil**	**Air movement speed, m/s, APR2 No. 25, 60 cm from the soil**	**Note**
180	9.7	5.8	2.0	2.5	0.08	0.09	6.2	7.3	Numerous cracks 2-3mm.
143	5.52	12.6	1.0	0.2	0.0	0.0	3.1	3.2	Behind the support stand.
133	3.24	0.44	0.5	0.9	0.08	0.07	3.5	3.1	Crack 1-3mm
87	0.65	1.85	0.3	0.6	0.19	0.21	2.6	3.5	Crack 1-3mm.
85	2.52	1.85	0.3	0.5	0.2	0.2	2.7	3.8	Crack 2-3mm
70	14.1	21.5	0.5	0.4	0.47	0.54	1.9	1.8	A crack about 80 cm long and 0.5-1 cm wide
63	19.7	20.4	0.9	0.2	0.54	0.6	3.5	3.8	Crack about 50 cm long and 1 cm wide
40	2.74	3.54	1.5	1.7	0.56	0.58	3.8	3.8	Crack 2-5mm

*This approach makes it possible to show that the concentration at the level of 60 cm and on average over the cross section are the same/close

At low air speeds of up to 1 m/s, increased methane concentrations were recorded near the soil. The methane concentration is also influenced by the size and number of cracks. The resulting methane concentrations above 2% are not a reason why it is necessary to stop the operation of the longwall, since they were obtained directly at the point of methane inflow (close to the soil); with further distribution of methane, its concentration decreases.

3 Results and discussion

According to measurement data, it was established that the speed of air movement near the soil in places of methane inflow depends on the location relative to the support elements or other longwall equipment. The minimum value was 0.2 m/s, the maximum was 2.9 m/s, and the average value was 1.4 m/s. This speed promotes rapid dilution of methane. As the measurement altitude increases, the methane concentration values decrease sharply. The concentration of methane, recorded at a height of 0.6 m, at the outlet of the air stream from the longwall (support section No. 40), is not so much the fixation of gas from a local source, but rather the total value of methane obtained as a result of its accumulation along the entire length of the longwall from other sources. It is worth noting that the air speed at some points exceeds 6 m/s. The excess occurs due to local and frontal resistance of the area where the measurements were taken. It is also worth noting that the air speed given in the table is not the average speed in the section, but is measured at one point.

Methane concentration measurements were carried out to assess the contribution of local sources of methane inflow to the gas balance of the lava, but the method used has a number of disadvantages. The most critical drawback is the failure to exclude external factors that "blur the picture" and prevent methane flow from being determined. The air flow passing through the lava provides intense mixing of methane.

From the analysis of mine research data, it becomes obvious that it is necessary to quantify the flow of methane from local sources. This will give an understanding of the contribution of these sources to the gas balance of the excavation site. Based on this, the task was set to develop a device that would allow this operation to be performed. A prototype of a device for measuring methane flow from local sources was developed (Figure 3), eliminating the influence of air flow on local methane emissions. At the moment, its mine tests are being carried out.

Fig. 3. Prototype of a device for measuring the flow rate of methane from local sources.

A necessary condition for further research is the sampling of released gases from local sources. Analysis of these samples will eliminate the error of incorrectly determining the methane flow rate. The presence of other gases can distort the data on methane concentrations, and will also provide a deeper understanding of the processes occurring. In addition to measuring the quantitative characteristics of the released gases, it is also necessary to carry out a chemical analysis, which will determine their composition.

The locations of local gas emissions were also analyzed. Figure 4 shows diagrams of the lava section indicating these locations. The analysis showed that the locations of local sources of methane are located in the lava in almost all places. In some cases, measuring the methane concentration was impossible, since the release could only be detected by ear. It occurred behind support or other equipment, which prevented access.

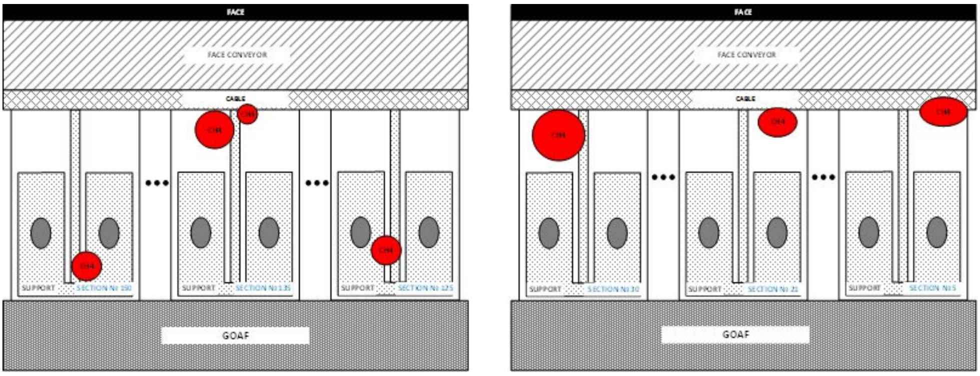

Fig. 4. Diagram of the lava section with indication of methane outlet points, view from above.

With further research, this fact may be an obstacle to determining the amount of methane released into the lava from the soil.

4 Conclusion

Analysis of the diagram indicating the points of methane inflow along the longwall floor (Figure 1) showed that methane inflow occurs along the entire length of the lava, mainly in the center. The mechanism of occurrence of local releases from longwall floor is not fully understood and requires additional research.

An analysis of the methane concentration and the speed of movement at the methane inflow points showed that the concentration reaches high values directly near the soil, but the flow of fresh air dilutes it to 0% in the immediate vicinity of the release point.

The number of local releases of gas with a high concentration of methane and the duration of their release are grounds to believe that the flow of methane from the soil can contribute to the gas balance of the lava. The impact of this source of methane emissions on the gas balance must be assessed.

For this kind of assessment, a prototype of a device for measuring methane flow from local sources was developed. At the moment, mine tests of the device are being carried out.

It is also necessary to conduct chemical analysis of gas samples obtained from local emissions. This will allow you to avoid errors when estimating the methane flow rate from this source.

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