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GAS CONTENT AND GAS-DYNAMIC CHARACTERISTICS POTASH STRATUM VI IN BELARUSKALI'S MINE 2

The problem of gas-dynamic phenomena is still urgent and relevant for the Starobin deposit of potash salts. Different types of phenomena are encountered on all mining levels. Thus, potash stratum III, which is the main working layer, is recognized as hazardous in terms of gas-dynamic phenomena of various types, and potash stratum I is considered hazardous due to sudden failure of mine floor rocks accompanied by gas emission. The data on the gas-dynamic hazard of potash stratum IV are yet unavailable, since this stratum remains off-balance, no work is carried out on this layer, and no relevant studies have been conducted. The solution to the problem of gas-dynamic phenomena always begins with the study of the gas content and gas-dynamic characteristics. Only after that, one can make recommendations on mining operation safety, and can select the most effective and least expensive ways to predict and prevent gas-dynamic phenomena. This article presents the studies into the gas content and gas-dynamic characteristics of free gases in potash stratum IV. The studies were carried out during getting access to potash stratum IV via a ramp and during development driving. In addition to individual data, the summary studies of the gas content and initial rate of gas release as the most significant characteristics are also presented. An assumption is made about the most hazardous areas of underground openings, where the accumulation of free gas is likely to happen. The suitable methods for preventing gas-dynamic phenomena during development driving in the conditions of potash stratum IV are considered. As the preliminary recommendations, it is proposed to perform drilling of degassing holes in the floor of underground openings, at interfaces and in the places of expansions the best process-oriented and most effective method.

Keywords: *Starobin deposit of potash salts, potash stratum IV, sylvinite layers, rock salt layers, free gas, gas content, initial gas release rate, free gas pressure, near-contact gas accumulations, gas-dynamic phenomena, floor rock destruction, degassing holes*
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Introduction

Currently, to maintain volume production of potash fertilizers and to preserve the position of one of the world leaders in potassium industry, Belaruskali's Mine 2 begins extraction of potash stratum IV (**Fig. 1**). Despite the fact that potash stratum IV propagates throughout the mine field [1–6], due to its deep occurrence and complex structure, it still belongs to the off-balance sheet. There have not been any data so far on the gas content and gas-dynamic characteristics of rocks in potash stratum IV, since no relevant studies have been conducted.

Currently, the access to potash stratum IV is got in the mine field of Mine 2. Here, 4 sylvinite layers in the lower part of the stratum are planned to be mined out (**Fig. 2**). Even at the stage of accessing via ramps, the issue of mining safety became evident. It should be noted that potash stratum III, which lies above, is hazardous in terms of gas-dynamic phenomena. From the practice of mining, it is known that gas-dynamic hazard increases with the depth of mining as the rock pressure increases [7–12]. In this regard, the study of the gas content of rocks in potash stratum IV is of not only scientific, but also practical interest.

Potential (natural) gas-dynamic hazard of rocks of potash stratum IV. It is known that gas-dynamic phenomena are a big problem in metal mining and in coal mining [12–19]. There are no universal ways to prevent these phenomena and the solutions adopted for coal seams are not suitable for salt rocks. Due to the fact that these phenomena occur suddenly and have a high power, they pose a serious threat to the lives of miners and can have catastrophic consequences [7–23].

Due to the fact that the rocks between potash stratums III and IV have not been studied and there is no any information about the content of free gas in them, the temporary recommendations for safe mining operations were developed for access ramps [24]. In addition, all work on the ramps was carried out under mandatory scientific supervision. Near the face in the underground openings, exploratory holes were drilled in the floor, and the gas-dynamic parameters of underlying rocks were studied. When necessary, the mining safety measures were adjusted, and only then the mining operations on the ramps were resumed. The work was carried out only in rocks with the revealed gas content and gas-dynamic characteristics. As soon as mining approached unexplored rocks, the operations were stopped and new studies were conducted.

However, all recommendations on mineral access lost their relevance in potash stratum IV as no development heading was assumed to be carried out there.

The gas content and gas-dynamic characteristics of rocks of potash stratum IV have not been studied so far, and there is no information about the quantitative indicators of these values. In this regard, the potential gas-dynamic hazard of potash stratum IV was accepted and evaluated similar to the gas-dynamic hazard of rocks of potash stratum III. Rocks of potash stratum IV are considered potentially hazardous in terms of gas-dynamic phenomena by the following criteria: the increase in the pressure as one of the gas-dynamic hazard factors by about 3.74 MPa (the increase in the depth of potash stratum IV by about 170 m compared to potash stratum III); the presence of relatively thick halopelite interlayers in sylvinite and salt layers, which can be associated with contact accumulations of free gases; the zones of substitution of sylvinite layers with rock salt, indicating epigenetic processes in rocks of potash stratum IV under the influence of water solutions possibly saturated with gas; the presence of clay–carbonate packs 2, 4 and 6 in underlying rocks of potash stratum IV (the numbers of packs according to the accepted geological section), which can be sources of gas-saturated water solutions; the presence of rock salt layers in the upper part of the stratum, which prevent free gas flow into the overlying rocks of potash stratum IV. All this creates prerequisites for the accumulation of free gas in potash stratum IV and initiates

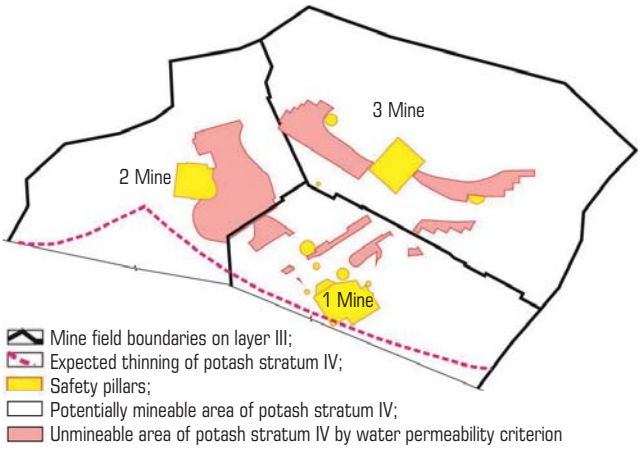

Fig. 1. Potentially mineable sites of potash stratum IV at the Starobin deposit of potash salts

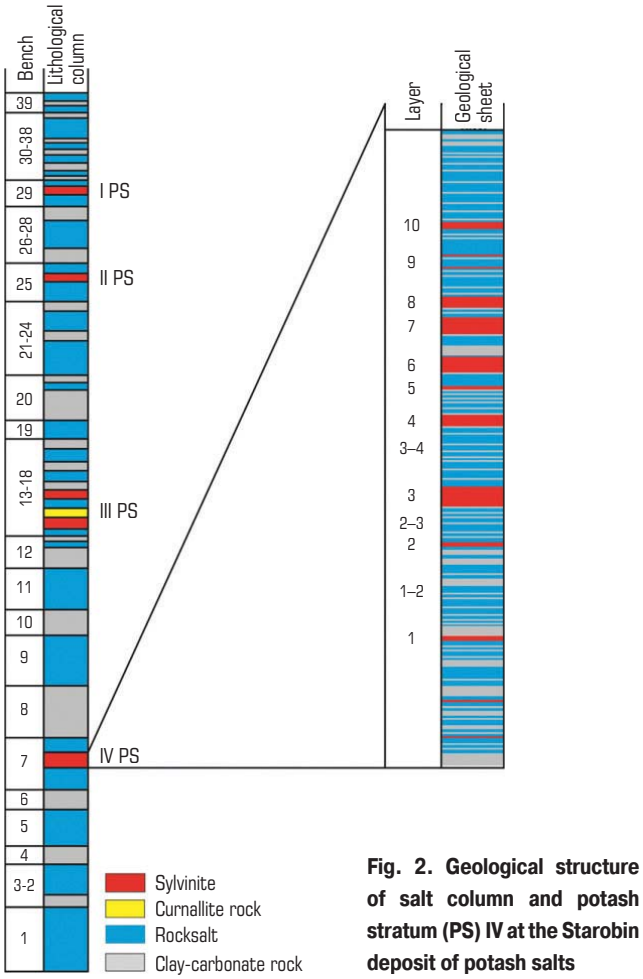

Fig. 2. Geological structure of salt column and potash stratum (PS) IV at the Starobin deposit of potash salts

foci of gas-dynamic phenomena. As a result, both development heading and stoping can be accompanied by various gas-dynamic phenomena. Therefore, it is necessary to study the free gas content and gas-dynamic characteristics of rocks in potash stratum IV, and then, on the basis of the data obtained, to develop measures to ensure safe mining operations.

Methodology

The free gas content and gas-dynamic characteristics of salt rocks of potash stratum IV were studied in-situ using the well-known procedure developed at the Mining Institute of the Ural Branch of the Russian Academy of Sciences [25]. The studies of gas content were carried out in boreholes drilled both in the floor and sidewalls of development drives to collect the data on the gas content and gas dynamic characteristics in each layer separately. This is necessary to identify layers with the highest gas content.

After determining gas flow pressure in a calibrated hole of a digital pressure gauge in mine conditions and incremental gas pressure in a fully sealed hole (well) in laboratory conditions, on the basis of the obtained data, the gas content, the initial gas release rate and the gas pressure in rock mass were calculated.

The article presents the results of research at the stage of getting access to mineral deposit via a ramp and during development heading in potash stratum IV.

Gas content and gas-dynamic characteristics of rocks of potash stratum IV at the stage of accessing. In the ramp, as soon as the operations reached the depth of development drives in potash stratum IV, the first studies of gas content and gas-dynamic characteristics were carried out [26]. At the test site, the roof of the ramp was located in sylvinite layer 8, and the floor was located in rock salt layer 3–4 below sylvinite layer 4 (**Fig. 3**).

The holes were drilled in the floor of the ramp, at a distance of 2.5 m from each other. The results of the borehole studies are compiled in **Table 1**.

The values obtained in the depth intervals of 1.0–2.0 m and 2.0–3.0 m are of the greatest interest. According to the data of the geological service of the mine, at this depth there are salt rock layers 2-3 and 3-4, and in-between sylvinite layer 3. It is obvious that here we have the most gas-saturated floor rocks in the stopes in potash stratum IV. Since free gases occur at the contacts of the layers, we can draw preliminary

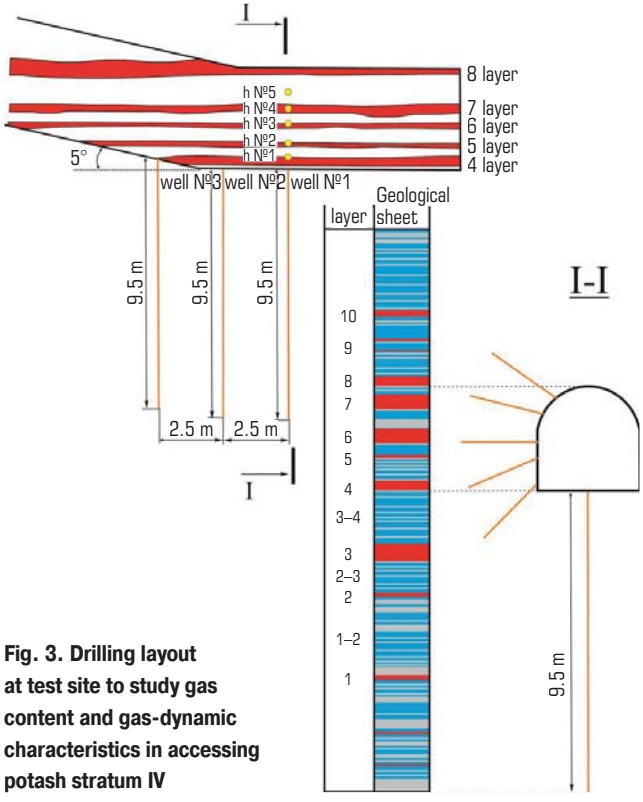

Fig. 3. Drilling layout at test site to study gas content and gas-dynamic characteristics in accessing potash stratum IV

Table 1. Resultant gas contents and gas-dynamic characteristics of rocks in potash stratum IV in the ramp floor

Drilling interval, m	Well No. 1			Well No. 2			Well No. 3		
	Gas content, m^3/m^3	Initial gas release rate, l/min	Gas pressure, MPa	Gas content, m^3/m^3	Initial gas release rate, l/min	Gas pressure, MPa	Gas content, m^3/m^3	Initial gas release rate, l/min	Gas pressure, MPa
0–1.0	0.15	3.87	0.25	0.20	0.18	0.19	0.10	0.40	0.19
1.0–2.0	3.42	2.41	0.22	0.36	0.19	0.19	0.33	0.98	0.19
2.0–3.0	2.7	2.62	0.23	0.29	0.83	0.19	0.30	0.66	0.19
3.0–4.0	0.3	0.73	0.19	0.22	0.65	0.19	0.29	0.72	0.19
4.0–5.0	0.2	0.42	0.19	0.2	0.47	0.19	0.17	0.45	0.19
5.0–6.0	0.18	0.35	0.19	0.13	0.54	0.19	0.13	0.30	0.19
6.0–7.0	0.15	0.39	0.19	0.11	0.29	0.19	0.11	0.28	0.19
7.0–8.0	0.18	0.22	0.19	0.12	0.20	0.19	0.13	0.19	0.19
8.0–9.0	0.15	0.29	0.19	0.11	0.18	0.19	0.13	0.20	0.19
9.0–9.5	0.18	0.31	0.19	0.13	0.24	0.19	0.11	0.24	0.19

conclusions that the contacts of sylvinite layer 3 with rock salt layers 2-3 and 3-4 are the most gas-saturated.

The reduced values of the gas content and gas-dynamic characteristics of salt rocks according to the measurements in wells No. 2 and No. 3 are due to the degassing effect of previously drilled well No. 1. Apparently, if preventive degassing drilling is necessary in the floor of the ramp, the drilling step can be made more than 2.5 m. However, to clarify this indicator, it is necessary to conduct special studies.

The maximum values of the gas-dynamic characteristics of rocks, namely, the free gas pressure of 0.25 MPa and the initial gas release rate of 3.87 l/min, are also confined to rock salt layer 3-4. In addition, the increased values of the gas-dynamic characteristics of rocks were found in rock salt layer 2-3, where the free gas pressure reached the value of 0.24 MPa and the initial gas release rate was 2.41 l / min.

To study the gas content of sylvinite layers and rock salt layers located above rock salt layer 3-4 (sylvinite layers 4, 5, 6, 7 and 8 and rock salt layers 4-5, 5-6, 6-7 and 7-8), exploratory holes No. 4–8 were drilled and 25 measurements were made. The results of the experiment are given in **Table 2**.

In general, the values of the gas content and gas-dynamic characteristics of salt layers 4-8 are not high. Only rock salt layer 7-8 stands out. This layer lies almost in the roof of the ramp, and the measurements were carried out near its boundary (up to 1.0 m). Apparently, there were stratifications of rocks along the contact of layers 7-8 and 8, or along clay layers in the rock salt layer, and migration of near-contact gas along these stratifications took place. This should be taken into account when developing recommendations for safe mining operations, since under certain conditions, for example, in case of long spans, or at junctions, it is possible that foci of gas-dynamic phenomena can appear in the roof rocks of the underground openings.

Gas content and gas-dynamic characteristics in development drives. During development of potash stratum IV, we almost immediately faced two interrelated problems: the floor rock heaving and destruction accompanied by gas release. The floor rock heaving is especially frequent at junctions and at expansions of underground openings. In undercutting, it turned out that the depth of stratification in the floor was about thirty

Table 2. Maximum values of gas content and gas-dynamic characteristics in potash stratum IV in the ramp wall

Layer	Gas content, m^3/m^3	Initial gas release rate, l/min	Gas pressure, MPa
8	0.17	0.17	0.191
7-8	0.23	1.03	0.193
7	0.15	0.16	0.191
6-7	0.17	0.57	0.191
6	0.11	0.13	0.190
5-6	0.11	0.13	0.190
5	0.15	0.14	0.190
4-5	0.21	0.97	0.192
4	0.15	0.17	0.191

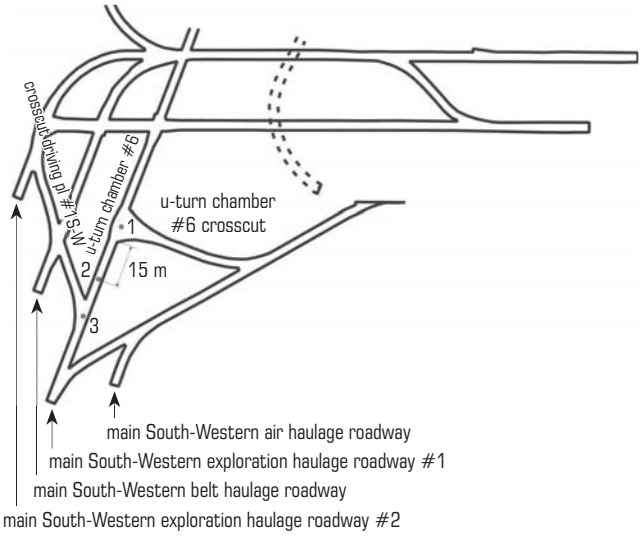

Fig. 4. Layout of experimental studies of gas content and gas-dynamic characteristics in potash stratum IV in development drives

centimeters, the stratification and heaving of the floor went through the layers of halopelites in rock salt layer 3-4 and minor stratification was observed at the contact of layers 3-4 and 3. These stratifications can accumulate free gas contained in rocks, which can lead to gas-dynamic phenomena in the floor rocks.

The gas content studies in the floor rocks of the development drive passing through rocks of potash stratum IV were carried out in turn chamber No. 6 (point 1), in the main southwest exploration and haulage drift No. 1 (point 2) and at the junction of the drift with entry No. 1 (point 3) (**Fig.4**).

It should be noted that in a single underground opening—the main southwest exploration and haulage drift (point 2) at the test site, a noticeable heaving of the floor rocks was visually observed, indicating stratification and degassing of rocks. The test drilling reveled no gas emission in the floor rocks.

The research hole in turn chamber No. 6 (point 1) was drilled in the floor in the center of the drive. During drilling, the intense gas release was recorded, accompanied by the outflow of chips from the hole and by the drilling tool jolts. In total, 7 measurements of gas content and gas dynamic characteristics in the floor rocks were carried out in this hole.

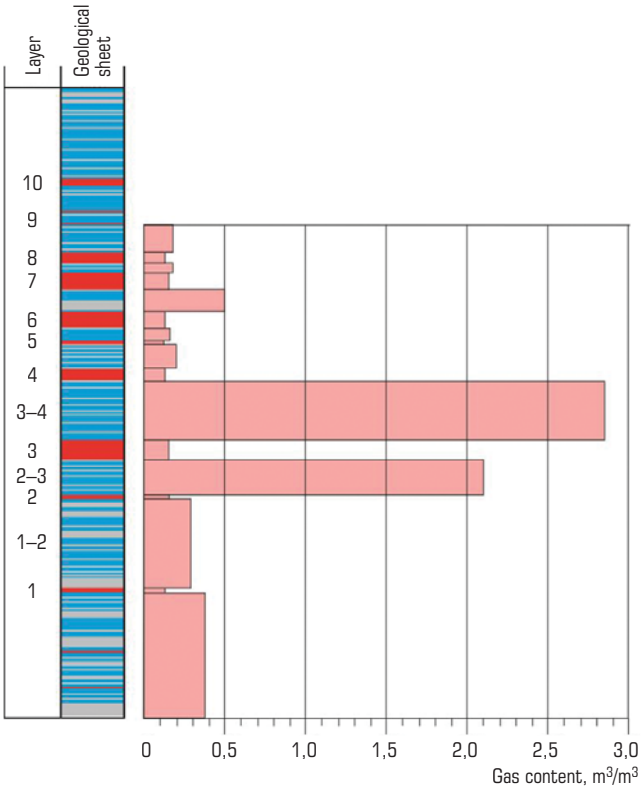

Fig. 5. Free gas content of rocks of potash stratum IV in the mine field of Mine 2

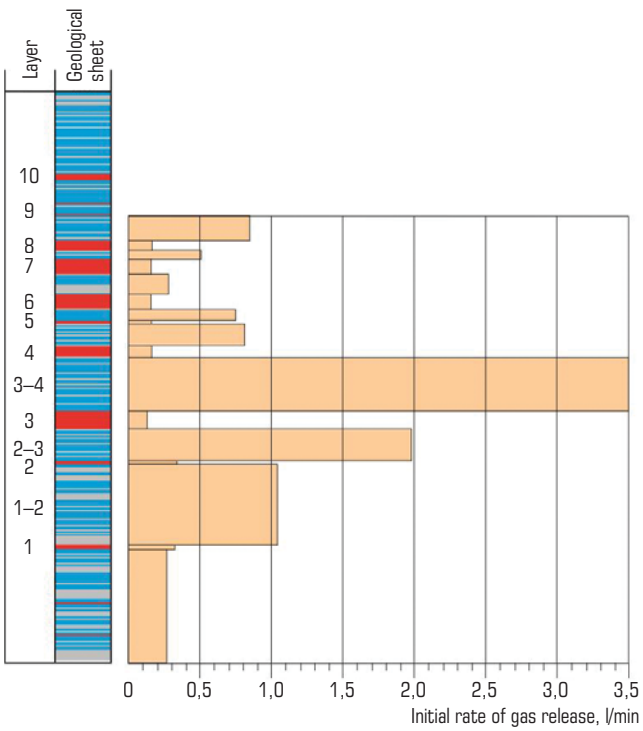

Fig. 6. Initial rate of gas release from rocks of potash stratum IV in the mine field of Mine 2

At this site, the gas content of rock salt layer 3-4 varies from 0.18 m^3/m^3 to 0.78 m^3/m^3, reaching a maximum value at the contact with sylvinite layer 3. The gas content of sylvinite layer 3 is 0.23 m^3/m^3, and the gas content of rock salt layer 2-3, sylvinite layer 2 and rock salt layer 1-2 varies from 0.17 m^3/m^3 to 0.26 m^3/m^3. The maximum value of the initial gas release rate was observed at the contact of sylvinite layer 3 with rock salt layer 3-4 and was 0.72 l/min. The free gas pressure in the seal interval of 1.5–2.0 m in the test hole was 0.2 MPa, and in all other seal intervals, the pressure of the free gases varied in the range of 0.19–0.192 MPa.

We carried 14 measurements of the free gas content and gas-dynamic characteristics at the junction of main southwest exploration and transport drift No. 1 with entry No. 1 (point 3). The maximum free gas contents in this study area were also observed at the contact of layers 3-4 and 3 and were 2.67 m^3/m^3. The maximum value of the initial gas release rate (2.19 l/min) was measured in this seal interval as well. The free gas pressure there was 0.24 MPa. Throughout the rest of the section, at study point No. 3, the gas content and gas-dynamic characteristics were not significant.

The data obtained in the development drive on potash stratum IV are consistent with the results of rock studies conducted in the ramp. Here, too, the most gas-saturated is the contact of sylvinite layer 3 with rock salt layer 3-4.

The general results of both tests are shown in **Figures 5** and **6**. Figure 5 shows the gas content of each of the studied layers of potash stratum IV, and **Fig. 6** shows the initial gas release rate.

The difference in the gas content and in the initial rate of gas release in different layers is clear, and it is clear that the highest gas content is a feature of rock salt layers 3-4 and 2-3. The contacts of these layers with sylvinite layer 3 are gas-saturated and it is here that the formation of foci of gas-dynamic phenomena is possible. The probability of these phenomena is higher in the layers adjacent to the floor of the development drive.

Considering the results obtained, we can recommend a set of measures for the safe open pit and underground mining of potash stratum IV. These measures include overcutting at a higher located roof, to create a thicker protective pack in the floor. In addition, it is possible to drill degassing holes. However, these options have both advantages and disadvantages. Another layout of underground openings can complicate stoping and is associated with technological difficulties. In addition, to completely eliminate gas-dynamic phenomena, additional studies are required. It is necessary to determine the thickness of the protective pack, and it is also possible that this measure may lead to some other problems, because a gas-saturated layer is also found in the roof of the underground opening.

Degassing drilling is associated with additional work, but in general this measure solves the problem of rock degassing and it is quite process-oriented. To determine the distance between the degassing holes, it is necessary to find the radius of the drainage zone, and this requires additional research. The drilling depth should be such as to ensure that the contact of sylvinite layer 3 with rock salt layer 2-3 is over-drilled. With the existing depth of the excavation roof, the depth of the degassing holes is to be 3.0 m. The studies in different mine workings have shown that, first of all, it is necessary to degas the floor rocks at the junctions and in the places of expansion of underground openings. The development drive itself is 3.0 m wide, and apparently needs no degassing.

Conclusions

To sum up, we can draw the following conclusions:

1. The gas content of the clay–halite layers located below sylvinite layer 1, as well as rock salt layer 1-2 varies from 0.11 m^3/m^3 to 0.50 $m^3/$

m^3, the gas content of sylvinite layers 1 and 2 varies from 0.12 m^3/m^3 to 0.17 m^3/m^3. The gas content of rock salt layer 2-3 varies widely—from 0.30 m^3/m^3 to 2.70 m^3/m^3, reaching the maximum at the contact with sylvinite layer 3. The gas content of sylvinite layer 3 does not exceed 0.30 m^3/m^3. The free gas content of rock salt layer 3-4 ranges between 0.15 m^3/m^3 and 3.42 m^3/m^3, reaching the maximum at the contact with 3 sylvinite layer 3. The gas content of rocks of sylvinite layer 4 varies from 0.11 m^3/m^3 to 0.15 m^3/m^3. The gas content of rock salt layer 4-5 varies from 0.17 m^3/m^3 to 0.21 m^3/m^3. The gas content of sylvinite layers 5, 6, 7 and 8 varies from 0.11 m^3/m^3 to 0.17 m^3/m^3. The gas content of rock salt layers 4-5, 5-6, 6-7, 7-8 and 8-9 varies from 0.11 m^3/m^3 to 0.23 m^3/m^3, reaching the maximum in rock salt layer 8-9.

2. Rocks of potash stratum IV are characterized by the following gas-dynamic characteristics: the initial rate of gas release varies from 0.18 l/min to 3.87 l/min, and the pressure of free gases varies from 0.19 MPa to 0.25 MPa. The maximum values of the gas-dynamic characteristics of rocks—the free gas pressure of 0.25 MPa and the initial gas release rate of 3.87 l/min—confined to rock salt layer 3-4. Furthermore, the increased values of the gas-dynamic characteristics of rocks were found in rock salt layer 2-3, where the pressure of free gases reached a value of 0.24 MPa and the initial gas release rate was 2.41 l/min. The layers of rocks located below sylvinite layer 1, sylvinite layers 1 and 2, rock salt layer 1-2 are characterized by the initial gas release rates not exceeding 0.47 l/min and by the free gas pressure not higher than 0.19 MPa. The initial rate of gas release from sylvinite layers 4, 5, 6, 7 and 8 and rock salt layers 4-5, 5-6, 6-7, 7-8 and 8-9 varies from 0.13 l/min to 1.03 l/min, reaching its maximum in rock salt layer 8-9. The pressure of free gases does not exceed 0.193 MPa.

3. Free gas accumulations are found in the rocks of rock salt layers 2-3 and 3-4 at the contact with sylvinite layer 3. This presents a potential hazard of gas-dynamic phenomena during development driving. As a measure to prevent gas-dynamic phenomena from the floor of the development drive, it is recommended to conduct degassing drilling at the interfaces and in the places of expansions of the drives. The depth of the holes should be such that to provide over-drilling of the contact of layers 3 and 2-3.

Acknowledgment

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References

1. Makhnacha A. S. et al. Geology and petrography of potash salts of Belarus. Minsk : Nauka I tehnika, 1969. 367 p.
2. Gretskiy R. G., Vysotsky E. A., Kislik V. Z. et al. Potash salts of the Pripyat trough. Minsk : Nauka i tehnika, 1984. pp. 124–125.
3. Vysotsky E. A., Garetskiy R. G., Eroshina D. M. et al. Devonian salt-bearing formations of the Pripyat trough. Minsk : Nauka I tehnika, 1982. 208 p.
4. Vysotsky E. A., Gubin V. N., Kutyrlo V. E. Economic and geographic aspects of the potash industry in the world. *Vestnik BGU*. 2007. No. 1. pp. 90–96.
5. Vysotsky E. A., Gubin V. N., Smichkin A. D. et al. Potassium salt deposits in Belarus: Geology and rational use of mineral resources. Minsk : BGU, 2003. 264 p.
6. Smichkin A. D., Zubov V. P., Kalugin P. A. et al. Process flowsheets in Belaruskali mines : Current condition, problems and prospects. *Gorniy Zhurnal*. 2003. No. 7. pp. 45–50.
7. Proskuryakov N. M. Rock and gas outbursts in potash mines. Moscow : Nedra, 1980. 263 p.
8. Kovalev O. V., Livenskiy V. S., Bylino L. V. Safe potash mining. Minsk : Polymya, 1982. 96 p.
9. Proskuryakov N. M., Kovalev O. V., Mescheryakov V. V. Gas-dynamics control in potash ore. Moscow : Nedra, 1988. 239 p.
10. Proskuryakov N. M. Ground control. Moscow : Nedra, 1991. 368 p.
11. Andreiko S. S., Ivanov O. V., Litvinovskaya N. A. Prediction and prevention of gas dynamic events in preparatory drives in underminedsalt rock mass: Monograph. Perm: Publishing House of Perm, National Research Polytechnic University, 2015. 159 p.
12. Kai Wang, Feng Du. The classification and mechanisms of coal–gas compound dynamic disasters: A preliminary discussion. *International Journal of Mining and Mineral Engineering*. 2019. Vol. 10, No. 1. pp. 68–84.
13. Black D. J. Review of coal and gas outbursts in Australian underground coal mines/ International *Journal of Mining Science and Technology*. 2019. Vol. 29, Iss. 6. pp. 815–824.
14. Liang Chen, Enyuan Wang, Jianchun Ou. et al. Coal and gas outburst hazards and factors of the No. B-1 Coalbed, Henan, China. *Geosciences Journal*. 2017. Vol. 22, No. 1. pp. 171–182.
15. Zhou Peiling, Yinghua Zhang, Zhi'an Huang, Yukun Gao, Wang Hui. et al. Coal and gas outburst prevention using new high water content cement slurry for injection into the coal seam. *International Journal of Mining Science and Technology*. 2017. Vol. 27(4) pp. 669–673.
16. Zakharov V. N., Malinnikova O. N. Outbursting risk in face areas of gas-bearing coal seams under mining. *Gornyi Zhurnal*. 2018. No. 12. pp. 81–85.
17. Odintsev V. N., Makarov V. V. Dynamic fracture of gas-bearing coal seam during zonal disintegration. *Journal of Mining Science*. 2020. Vol. 56. No. 6. pp. 932–946.
18. Kubrin S. S. Multifunction system to predict hazardous gas-dynamic phenomena in coal mines. *Gornyi Zhurnal*. 2017. No. 11. pp. 97–100.
19. Shadrin A. V. Geophysical criterion of pre-outburst crack propagation in coal beds. J*ournal of Mining Science*. 2016. Vol. 52, No. 4. pp. 670–682.
20. Tarakanov V. A., Golovaty I. I., Beresnev S. P., Andreiko S. S., Ivanov O. V. Gas content of potash stratum III at the Starobin deposit. *Gornyi Zhurnal*. 2010. No. 8. pp. 25–27.
21. Beresnev S. P., Senyuk V. V., Gonchar V. I., Andreiko S. S., Litvinovskaya N. A. Mechanism of gas-dynamic phenomena-hazardous zones in potash stratum I. *Gornyi Zhurnal*. 2010. No. 8. pp. 31–33.
22. Podlesny I. A., Beresnev S. P., Andreiko S. S., Nekrasov S. V., Litvinoskaya N. A. Geomechanical modeling of sudden failure of floor rocks in underground openings. *Gornyi Zhurnal*. 2010. No. 8. pp. 28–30.
23. Barbikov D. V., Andreiko S. S., Ivanov O. V. et al. Dynamics of rock mass at the Krasnoslobodsk fault. *Gornyi Zhurnal*. 2018. No. 8. pp. 38–42.
24. Andreiko S. S. Prevention of gas-dynamic phenomena in cutting ramps to access potash horizon IV at the Starobin deposit of potash salts. Strategy and Processes of Georesources Development. Perm : GI UrO RAN, 2014. No. 12. pp. 227–229.
25. Zemskov A. N., Kondrashev P. I., Travnikova L. G. Natural gas at potash deposits and measures to combat them. Perm : Tipographiya kuptsa Tarasova, 2008. 414 p.
26. Litvinovskaya N. A. Studies of gas content and gas-dynamic characteristics of potash stratum IV in the area of ramps in Belaruskali's Mine 2 field. *Gornoe ekho*. 2019. No. 2(75). pp. 79–82. EM