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ПАРАМЕТРЫ ПРОФИЛАКТИЧЕСКОЙ ДЕГАЗАЦИИ ПОРОД ПОЧВЫ ГОРНЫХ ВЫРАБОТОК ПРИ СЛОЕВОЙ ОТРАБОТКЕ ТРЕТЬЕГО КАЛИЙНОГО ПЛАСТА НА РУДНИКАХ ОАО «БЕЛАРУСЬКАЛИЙ»

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PARAMETERS OF PREVENTIVE GAS REMOVAL FROM MINE BEDROCKS DURING THE LAYER MINING OF THE THIRD POTASH FORMATION AT MINES OF BELARUSKALI JSC

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potash mine, gas dynamic phenomena, prevention methods, mine, bedrock, Third potash formation, drift, layer mining, long face, reference pressure, metering station, sealer, gas content, initial gas release velocity, gas pressure, digital manometer, well, technological schemes of mining, preventive gas removal.

The article presents results of studies aimed to develop parameters for preventive gas removal of mine bedrocks occur during the layer mining of the Third potash formation in conditions of Belaruskali JSC mines. Development of parameters for preventive gas removal of bedrocks was carried out based on results of mine experimental studies of gas content, gas dynamic characteristics of bedrocks and experimental studies of dynamics of pressure of free gases under different mine industrial conditions of layer mining at the Third potash formation. A method of mine experimental research consider quantitative assessment of the indicators such as gas content of bedrocks on free gases, initial velocity of gas emission from bedrocks, pressure of free gases of bedrocks. Study of dynamics of change in time of pressure of free gases in bedrocks of the preparatory excavations were carried out in excavation poles of long faces that mine layers 2, 2-3 and 3 of the Third formation. That was done with help of measuring stations (packers) equipped for measuring the pressure of free gases in the measuring chambers by digital manometers. Based on results of mine experimental studies, regularities of formation of focuses of gas dynamic phenomena in bedrocks were established. Regularities consider various mining conditions of layer operation of the Third potash layer. Parameters of preventive gas removal drilling of wells into the bedrocks of preparatory excavations for long faces that mine layers 2, 2-3 and 3 of the Third potash layer in various geological and mining conditions have been developed. Parameters consider established regularities of formation of focuses of gas dynamic phenomena in bedrocks. Parameters of preventive gas removal drilling for various technological schemes for operation of the Third layer include a list of excavations in the long faces where preventive gas removal drilling should be applied and diameter, depth and distance between the degassing wells. Introduction of schemes of preventive drilling of degassing wells into the bedrocks of preparatory excavations of long faces that mine layers 2, 2-3, 3 of the Third potash layer allows to increase safety of mining operations at the mines of Belaruskali JSC.

Ключевые слова:
калийный рудник, газодинамические явления, способы предотвращения, горная выработка, почва, Третий калийный пласт, штрек, слоевая отработка, лава, опорное давление, замерная станция, герметизатор, газоносность, начальная скорость газовыделения, давление газа, цифровой манометр, скважина, технологические схемы отработки, профилактическая дегазация.

Приведены результаты исследований, целью которых являлась разработка параметров профилактической дегазации пород почвы горных выработок при слоевой отработке Третьего калийного пласта в условиях рудников ОАО «Беларуськалий». Разработка параметров профилактической дегазации пород почвы горных выработок производилась на основе результатов шахтных экспериментальных исследований газоносности, газодинамических характеристик пород почвы и экспериментальных исследований динамики изменения во времени давления свободных газов в породах почвы горных выработок в различных горнотехнических условиях слоевой отработки Третьего калийного пласта. Методикой шахтных экспериментальных исследований предусматривалась количественная оценка следующих показателей: газоносность пород почвы горных выработок по свободным газам; начальная скорость газовыделения из пород почвы; давление свободных газов в породах почвы. Исследования динамики изменения во времени давления свободных газов в породах почвы подготовительных выработок проводились в выемочных столбах лав, отрабатывающих слои 2, 2–3, 3 Третьего пласта с помощью замерных станций (пакеров), оборудованных для замера давления свободных газов в измерительных камерах цифровыми манометрами. На основании результатов шахтных экспериментальных исследований установлены закономерности формирования очагов газодинамических явлений в породах почвы горных выработок при различных горнотехнических условиях слоевой отработки Третьего калийного пласта. С учетом установленных закономерностей формирования очагов газодинамических явлений в породах почвы горных выработок разработаны параметры профилактического дегазационного бурения скважин в почву подготовительных выработок для лав, отрабатывающих слои 2, 2–3, 3 Третьего калийного пласта в различных геологических и горнотехнических условиях. Параметры профилактического дегазационного бурения для различных технологических схем отработки Третьего пласта включают: перечень выработок в выемочном столбе лавы, в которых должно применяться профилактическое дегазационное бурение; диаметр, глубину и расстояние между дегазационными скважинами. Внедрение схем профилактического бурения дегазационных скважин в почву подготовительных выработок лав, отрабатывающих слои 2, 2–3, 3 Третьего калийного пласта, позволяет повысить безопасность ведения горных работ на рудниках ОАО «Беларуськалий».

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Introduction

Today, there is a major part of the challenges that consider prevention of gas dynamic phenomena (GDP) and further improvement of mining safety at Belaruskali JSC is overcome. Over the past two decades, a significant contribution has been made to the study of nature, mechanisms of various types of GDP and ways to fight with them [1–15]. Effective prediction methods and methods for preventing known gas-dynamic phenomena have been developed [16–21]. However, in recent years mining practice on the Third potash layer in conditions of mines of Belaruskali JSC has shown that there is a new natural danger for miners such as gas-dynamic phenomena from the soil of preparatory and cleaning mines. Suddenness, high power, damaging factors in the form of flying at high speed pieces of rock, air waves and intensive release of natural combustible gases, no warning signs and precursors of gas-dynamic phenomena of this kind pose a serious threat to the life of miners. An example of sudden release of salt and gas from the soil at the area of a junction conveyor drift with an assembly drift of the long face No. 12a-2 (12th southern "A" panel, mine 4 RU) is shown on the Fig. 1. Due to the facts that GDP happened

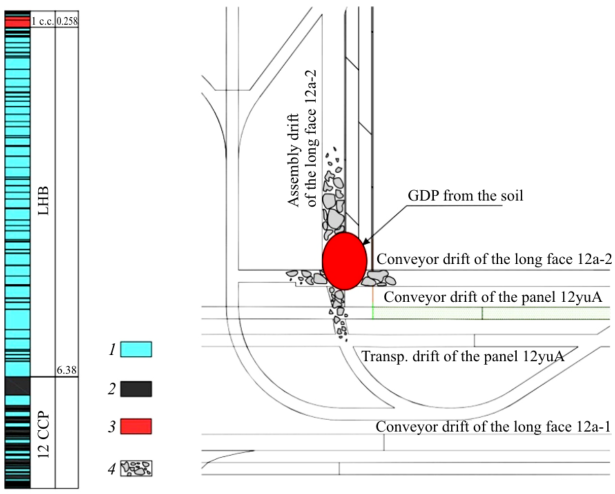

Fig. 1. Sudden release of salt and gas from the soil at the area of the conjunction of the conveyor drift with assembly drift of the long face No. 12a-2 (12th southern "A" panel, 4 RU mine): *1* – halite; *2* – clay; *3* – sylvinite; *4* – enclosing empty rock

from the soil there is an urgent need to research and develop both the mechanism of GDP emergence from the soil of mines and effective ways to prevent them. Many years' experience of mining on formations dangerous because of gas dynamic phenomena shows that only a thorough study of the nature of GDP from the soil of mines will allow substantiating effective measures to fight with them and determine possible ways to control dynamic destruction of a set of salt rocks [22-38].

The methodology for carrying out mine experimental studies of gas content, gas dynamic characteristics and dynamics of variation of pressure of free gases in the soil rocks of preparatory excavations in time

During the period 2015-2016 there were mine experimental studies of gas content and gas dynamic characteristics of soil rocks of mines as well as dynamics of time variation of pressure of free gases in the soil of preparatory excavations in the pillars of long faces while mining 2, 2-3, 3 layers of the Third formation at the mines 2, 3 and 4 of Belaruskali JSC. Studies were performed using the equipment of the Center of common use Center for Study of Geomaterial Properties of PNRPU.

There were experimental studies of gas content and gas dynamic characteristics of soil rocks of preparatory mines and the interface of the long face-drift performed during the minig of the Third potash formation. The technique included determination of gas content of soil rocks by free gases and gas-dynamic characteristics such as initial velocity of gas release and pressure of free gases. The technique was implemented by means of mine instrumental observations of gas release from wells with a diameter of 42 mm drilled into the soil of mines with simultaneous sampling of free gas. Studies of gas content and gas dynamics of soil rocks of the Third potash formation were carried out in preparatory excavations of long faces represented usually by conveyor, transportation, ventilation and filling drifts. The wells were drilled by intervals and immediately sealed at a distance of 0.5 m from the bottom of the well with the help of a seal. The gas released from the walls and face of a sealed well part entered the gas outlet pipe that precision portable digital manometer DPI-740 was connected to. Measuring ranges of DPI-740 manometer are as follows: atmospheric pressure – from 0.75 to 1.15 bar; absolute pressure – from

0.035 to 1.3; 2.6; 3,5 bar; maximum permissible pressure is 4 bar. Using the DPI-740 manometer, initial gas release velocity in a well is determined from the pressure created by the gas passing through a calibrated capillary hole. Increment of the gas pressure in a well was determined as well within 30 s after its sealing, i.e. initial gas pressure. Due to that, previously plotted graphs were used and gas content was determined by the dependence $X = f(P_g)$, where X is for gas content of rocks, m^3/m^3; P_g is for the value of initial gas pressure.

Gas pressure in soil rocks of the mines was calculated according to the known formula of L.S. Leibenzone

$$P_0 = P_2 \Bigg/ \left(\frac{2}{\mu+1}\right)^{\frac{\mu}{\mu-1}},$$

where P_2 is for measured initial gas pressure in the sealed part of the research well, MPa; μ is for the adiabatic exponent for a mixture of gases released from a set of salt rocks (μ ≈ 1,4).

The pressure of free gas in the soil was calculated for each interval along the length of the well. The DPI-740 instrument was used to measure the rate of gas flow from the research wells. A stopwatch recorded time of rate change. The obtained volume of gases released from the wells corresponds to the volume of the drainage zone around the well. In order to determine the component composition of gas released, at the same time a free gas sample is taken. Chemical analysis of the composition of free gases is carried out on a gas chromatograph. To analize the component composition of gases, modern gas chromatographs 450-GC (Varian, Inc) were used.

Study of the dynamics of pressure of free gases in soil rocks of the preparatory excavations were carried out in pillars of long faces that mine the layers 2, 2-3 and 3 of the Third formation at the mines 2, 3 and 4 RU of Belaruskali JSC. The method of mine experimental research included the drilling of special research wells into the rocks of the soil of the preparatory excavations of a long face with the subsequent equipment of measuring stations (packers). There is not only the drilling of vertical wells into the soil of mine during the drilling but precise location of the contact “layer of halite bedrock (LHB) – 12th clay-carbonate pack (12 CCP)” was determined. Depth of the wells for the equipment of measuring stations provided the re-drilling of the contact of the LHB-12 CCP. Design of the measuring stations is shown on the Fig. 2.

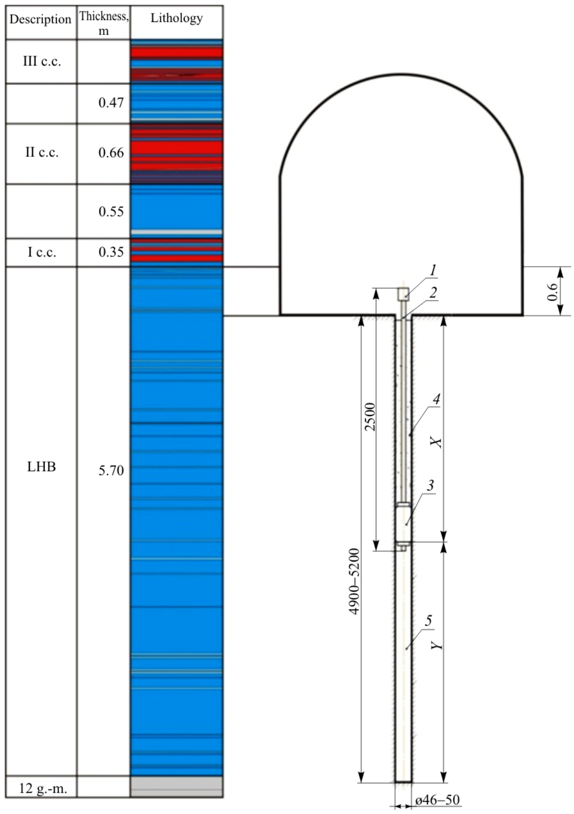

Fig. 2. Geological structure of rocks of the soil of mine excavations and design of measuring stations: *1* – plug (check valve); *2* – pipe; *3* – sealer; *4* – cement beaker; *5* – measuring chamber; 1st, 2nd, 3rd gas shutter (packer)

At the moment of equipment of measuring stations and the first measurement of the pressure of free gases, the distance to the line of a cleaning face of the lava in all cases exceeded 120 m, i.e. all the measuring stations were located outside the zone of front abutment pressure. Time between measurements of the pressure of free gases on the measuring stations varied from 2 to 13 days. Total time of observations of dynamics of the change in time of pressure of free gases in soil rocks of preparatory excavations of a long face was approximately 1.5-2 months. In order to measure the pressure of free gases on the measuring chambes of stations, a digital manometer Crystal XP2i was used. The manometer is designed to measure absolute, negative and positive excess pressure. The Crystal

XP2i digital pressure gauges can be used in field and laboratory conditions as reference measuring instruments. The main technical characteristics of the Crystal XP2i digital manometer are as follows: pressure measuring ranges from 0.1 to 70 MPa; temperature compensation over the entire measurement range; error ± 0.1 % of IW (in the range of 20 to 100 % of the scale), ± 0.02 % of the VPI (in the range of 0-20 % of the scale). An example of sampling using the Crystal XP2i digital manometer is shown on the Fig. 3.

Fig. 3. Measurement of the pressure of free gases on the measuring station using a digital manometer Crystal XP2i

In accordance with the technique of mine experimental studies of the dynamics of pressure of free gases in soil rocks of preparatory excavations, measurements were made when visiting the measuring station. Those measurements are the magnitude of long face movement determined by surveying marks placed on the side of the drifts of long faces and the distance from the measuring station to the line of the extraction face. Pressure readings of free gases in the measuring chambers of the stations were taken using the digital pressure gauge Crystal XP2i.

Results of mine experimental studies of gas content, gas dynamic characteristics and dynamics of variations of pressure of free gases in soil rocks of preparatory excavations in time

As a result of experimental studies at 2RU, 3RU and 4RU, it was established that the gas content and gas dynamic characteristics of halites vary unevenly in the geological section of a halite's bedrock burried in a soil of the Third potash stratum. The most gas containing layer of halite in a bedrock are a pack (set) of clay-salt interlayers, lying over the 12th clay-carbonate pack (12 CCP), with a thickness of approximately 0.4-0.5 m; a pack (set) of clay-salt interlayers lying in the central part of a layer of halite bedrock at the distance of approximately 4.0 m from the soil of the 1st sylvinite layer of the Third potash stratum, with a total thickness of approximately 0.4 m; contact of a layer of halite bedrock with 12 CCP. Free gases in a LHB are represented by contact clusters that are mostly formed during the mining of layers 2, 2-3 and 3 of the Third formation by long faces during the mining of the 4th sylvinite layer. The contact accumulations of free gases in the LHB are formed when long faces move away from the assembly drifts and at the junctions of the long face-drift. In addition, near-contact clusters of free gases are formed in the rocks of LHB on the junctions of the side drifts of long faces, that mine the layers 2, 2-3, 3 of the Third formation, with preparatory excavations for various purposes. The effect of mining on the gas content and gas dynamic characteristics of the rocks of LHB begins to affect in the zone of front abutment pressure which is approximately 120 m ahead the along face, that mine layers 2, 2-3 and 3 of the Third layer. There is a high gas content in the zone of front abutment pressure in the LHB up to 8.6 m^3/m^3, pressure of free gases up to 5.1 MPa and initial gas evolution rate up to 8.8 l/min [39]. A significant increase in the gas content, pressure of free gases and the initial rate of gas release (up to the gas release from the big cracks of rocks) from the LHB and SCP is confined to the stage when a long face moves away from the assembly drifts. During the mining of the excavation column it moves to junctions of a long face-drift and junctions of side drifts of long faces that mine layers 2, 2-3 and 3 of the Third formation with preparatory excavations for various purposes. For example, there are results of studies on the gas bearing capacity of rocks of a LHB over the depth of a research well located at the depth of 3.0 m from the bottom of a long face. As it seen from the Fig. 4, the contact of the LHB-12 CCP is found at a depth of 4.9 m. Untill the drilling depth of 4.0 m the gas content of a LHB varies in the range from 0.13 to 0.84 m^3/m^3 and reaches a maximum at a depth of 2.5 m. Then, there was an intensive gas release occurred from the LHB at the interval of depths of 4.0-4.5 m. The gas-bearing capacity of the rocks of LHB in this interval exceeded 5 m^3/m^3. After the entry of the contact with the 12 CCP, the gas content of rocks also exceeded 5 m^3/m^3. Results of measuring the initial gas release rate in the research well No. 7 showed that in the depth interval of 1.0-4.0 m initial gas release rate varied within 0.48-0.89 l/min. Intensive gas release is confined to a depth interval of 4.0-4.5 m, where the initial gas release rate reached a maximum value equal to 8.81 liters per minute. There is at the depth of 4.5-5.0 m, the initial rate of gas release was 8.28 l/min. At that, at the depth interval of 4.0-5.0 m a free gas pressure exceeded 0.380 MPa, which is a measuring limit of the DPI-740.

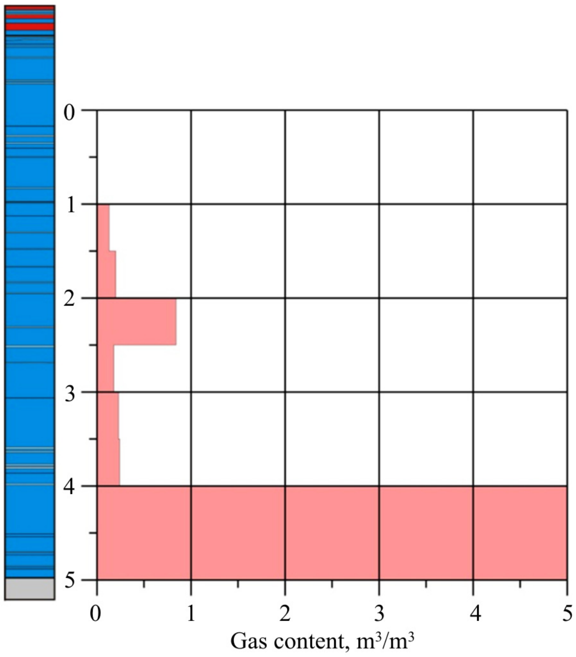

Fig. 4. Change in gas content of rocks according to the geological section of the LHB (3 m from the long face, well No. 7, a ventilation drift of the long face 13n-2, mine 3 RU)

During the experimental studies of dynamics of pressure in time of free gases in the soil rocks of preparatory excavations while processing the layers 2, 2-3 and 3 of the Third formation, it was established that dynamics of pressure of free gases in time in chambers of measurement stations outside the zone of the front abutment pressure from the working long face is predominantly increasing. Such a character of change in time of the pressure of free gases in rocks of the ventilation drift is caused, apparently, by the action of lateral abutment pressure from the adjacent mined excavation pillars or from the mined pillars along the 4th sylvinite layer. Pressure of free gases in chambers of measuring stations increases almost 2.5-3 times, reaches a value of 5.1 MPa and more in the zone of the front abutment pressure from the long face during the processing of layers 2, 2-3 and 3 of the Third formation. In the goaf part of a long face (in an unloading zone) behind the mating fittings, the pressure of free gases in the measuring chambers decreases almost to zero. A graph of change in pressure of free gases in the chamber of measuring station depending on distance to the breakage face No. 41-bottom that mine the layers 2, 2-3 and 3 of the Third layer in conditions of the 2 RU mine is shown on the Fig. 5.

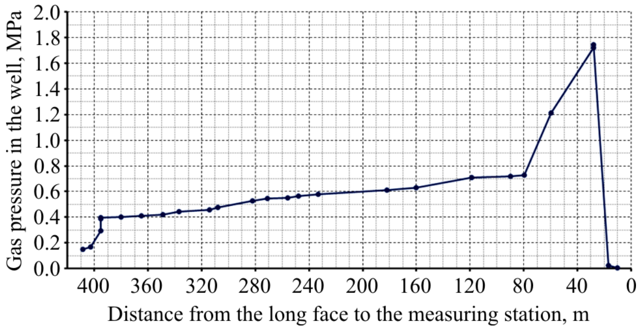

Fig. 5. Graph of change in pressure of free gases in a chamber of measuring station, depending on the distance to the long face No. 41-bottom

As it seen from the Fig. 5, the observations began at a distance from the line of the long face to a measuring station of 408.5 m. At the same time, pressure in a measuring chamber was 0.15 MPa. Then, as a long face approached a measuring station, a monotonous increase in pressure of free gases in a measuring chamber was observed. The increase was almost linear up to a value of 0.73 MPa to a distance of 79.5 m. After that, the graph shows a sharp increase in the value of pressure of free gases in a measuring chamber of measuring station to 1.22 MPa at a distance of up to the line of the long face No. 41-bottom of 59.5 m. Then, there is an increase in gas pressure in a chamber of measuring station to a maximum of 1.75 MPa at a distance of up to the line of the bottomhole of the long face No. 41-bottom equal to 28.0 m. At a distance of 17.0 m to the line of a long face, gas pressure in a measuring chamber has sharply decreased to 0.023 MPa. There is at the goaf of the long face pressure in a measuring chamber fell to zero in a direction of the goaf space at a distance of 19.0 m from the long face.

Results of the analysis of dynamics of pressure change of free gases in the chamber of measuring station in a long face pillar No. 41-bottom allow interpreting the data as given below. The growth of the pressure of free gases in the chamber of measuring station outside the zone of the front abutment pressure of the long face No. 41-bottom is caused, apparently, by the flow of gas into the zone of unloading the long face soil No. 41-bottom from the area of action of the lateral abutment pressure from the lava No. 41-top. As it is approached the measuring station of the lava face No. 41-bottom under the influence of the front abutment pressure, the gas pressure in the chamber of measuring station increased and reached its maximum of 1.75 MPa, with a distance up to the breakage of 28.0 m. Next, when the long face reaches the measuring station in the soil rocks there is a pressure gradient of free gases in the measuring chamber under the influence of the forward reference pressure from the long face No. 41-bottom exceeded a flow gradient in the surrounding rocks. That led to the gas flow from the measuring chamber into the surrounding rocks. Excess pressure in the measuring chamber was lowered first to 0.023 MPa, at the distance to the breakage face of 17.0 m, and then to zero in the unloading zone behind the long face junction. Almost the same regularities of dynamics of pressure changes in free gasses in measuring chambers of measuring stations in the excavation pillars of the long face that mine the layers 2, 2-3 and 3 of the Third layer were also established in the mines of 3 RU and 4 RU. Some differences were observed in terms of the maximum free gas pressure in the measuring chamber and distance in the reference pressure zone from the maximum pressure of free gases to the line of the long face.

Parameters of preventive degassing for prevention of gas-dynamic phenomena from the soil of mines

Results of shaft experimental studies of gas content, gas dynamic characteristics and dynamics of pressure changes of free gases in rock formations of mines during the mining of layers 2, 2-3 and 3 of the Third layer have shown that there are active stages of the processes of displacement, deformation of the massif and redistribution of rock pressure occur in the soil. At the same time, there are conditions created to increase the local fracturing and formation of stratifications of mined soil rocks as a result of shear and stretching along clay interlayers. In this area rocks of the soil do not yet have flow channels that could link them to rocks, where the effect of mining has appeared, i.e. while retaining the energy reserve of the compressed gas. Growth of gas pressure in rocks of mines in this area is facilitated by the abutment pressure on the soil rocks of the interworking accumulatios. In such mining conditions and at pressure of free gases in soil rocks, a dynamic type of destruction in the form of sudden emissions of salt and gas or sudden destruction of soil rocks accompanied by gas release.

In order to prevent gas-dynamic phenomena coming from the soil during the mining of the layers 2, 2-3 and 3 of the Third layer technological schemes have been developed taking into account the various options for use of the column system of development for conditions of mines of Belaruskali JSC. The technological schemes are as follows: preventive drilling of degassing wells into the soil of the assembly (demounting) drift and mating of the assembly (demounting) drift with conveyor, ventilation and other drifts and excavations located in the field a long face; preventive drilling of degassing wells into the soil of the conveyor or adjacent drift and a long face drift along the length of the pillar in case of bulk working of layers 2, 2-3 and 3 of the Third formation (with or without mining of the 4th sylvinite layer); preventive drilling of degassing wells into the soil of conveyor, ventilating and filling drifts and interfaces with selective excavation of layers 2, 2-3 and 3 of the Third formation (with no mining of the 4th sylvinite layer) with long face backfilling; preventive drilling of degassing wells into the soil of conveyor, ventilation and filling drifts and junctions during the layer excavation of the Third layer with selective mining of layers 2, 2-3 and 3 by the lower long face and goaf backfilling in the separate preparation of layer long faces; preventive drilling of degassing wells into the soil of conveyor and ventilation drifts and junctions during the layered excavation of the Third potash formation by long faces of variable extractable thickness with complete collapse of the roof (excavation of layers 2, 2-3 and 3 under the mining, the area of long face rise on the soil from layers 2, 2-3 and 3 on the 4th sylvinite layer and excavation of the 4th sylvinite layer). Thus, there is a scheme of preventive drilling of degassing wells into the soil of the assembly (demounting) drift and junction of the assembly (demounting) drift with conveyor, ventilation and other drifts and excavations located in the field of the long face on the Fig. 6. As it seen from the Fig. 6, in order to prevent gas-dynamic phenomena from the soil when the long face that mine the layers 2, 2-3 and 3 of the Third potash reservoir moves away from the drifting drill, preventive drilling of the degassing wells into the soil of the assembly drift and junction of the assembly drift with conveyor, ventilation and other drifts and excavations located in the field of a long face.

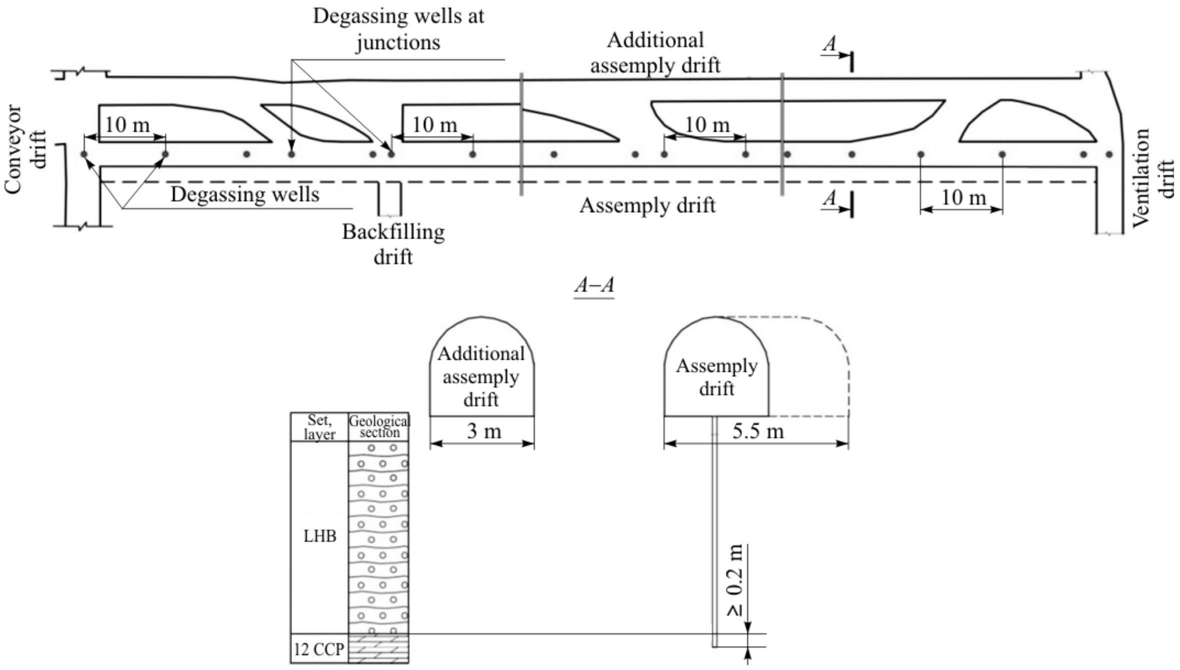

Fig. 6. Scheme of preventive drilling of degassing wells into the soil of an assembly (demounting) drift and junction of an assembly (demounting) drift with conveyor, ventilation and other drifts and excavations located in the field of a long face

Degassing of the soil of the assembly drift and junctions of the assembly drift with conveyor, ventilation and other drifts and excavations located in the field of a long face is carried out prior to its expansion by prophylactic drilling of vertical degassing wells into the soil of the assembly drift and junctions with parameters such as diameter of degassing wells of at least 40 mm; distance between the degassing wells is not more than 10.0 m; depth of the wells should ensure that the LHB-12 CCP contact is re-drilled by at least 0.2 m. Drilling of degassing wells is carried out along the axis of the assembly drift or on any side of it. If drilling of vertical degassing wells into the soil of an assembly (dismounting) drift of a long face is impossible, then it is allowed to drill inclined degassing wells into the soil of an additional drift (excavation) adjacent to it. In this case, the bottom of the well must enter the roof of the 12th clay-carbonate pack to a depth of at least 0.2 m below the soil of the assembly (demounting) drift.

Parameters of preventive degassing drilling of wells into the soil of preparatory excavations have been developed for long faces on layers 2, 2-3 and 3 of the Third potash formation in various geological and mining conditions. The introduction of schemes of preventive drilling of degassing wells into the soil of the preparatory excavations of long faces that mine the layers 2, 2-3 and 3 of the Third potash formation allows increasing the safety of mining operations at the mines of Belaruskali JSC.

Conclusion

The results of shaft experimental studies of gas content, gas dynamic characteristics and dynamics of pressure changes of free gases in rock formations of mines during the mining of layers 2, 2-3 and 3 of the Third formation allowed establishing regularities in soil rocks of processes of redistribution of free gas pressure. It is established that in the soil rocks of mining workings conditions are created to increase local fracturing and formation of stratifications of the mining soil rocks as a result of shear and stretching along clay interlayers. The reserve of energy of the compressed gas is stored in the soil rocks. Growth of gas pressure in rock formations in mines in such areas is facilitated by lateral and forward abutment pressure, which ultimately leads to a dynamic form of destruction in the form of sudden release of salt and gas or sudden destruction of soil rocks accompanied by gas emission. In order to escape dynamic types of destruction of soil rocks of mines in the form of sudden salt and gas emission or sudden destruction of soil rocks accompanied by gas release during the mining of layers 2, 2-3 and 3 of the Third layer, it is necessary to apply preventive degassing of the soil rocks of assembly, side and backfilling drifts, located in the field of long faces, as well as conjugations of drifts located in the field of long faces with other drifts and excavations of various purposes with the parameters that are as follows: diameter of degassing wells of at least 40 mm; distance between degassing wells is not more than 10.0 m; depth of wells should provide a re-drilling of the contact of the LHB-12 CCP by at least 0.2 m.

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