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Research of Emission Methane From Coal-Bearing Rock

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Abstract:

Many years of experience in the development of gas-bearing coal seams in the Donbass has shown that not in all cases the safety of mining is ensured, even when all the requirements of regulations are met. Analysis of the state of this problem indicated its connection with various areas of mining science, the provisions of which are insufficiently taken into account in the recommendations of regulations. These include the establishment of conditions and forms of gas in coal and host rocks for mining, factors that cause gas manifestations in coal mines, the relationship of the process of gas evolution with displacement and stress of counterfeit rocks, features of formation and interconnection of landslide zones and gas evolution in counterfeit rocks. A study of the geological characteristics of Donbass as a gas-coal field, during the development of gas-bearing strata containing coal of almost all brands of a number of metamorphism and possible gas release into mine workings from free gas reservoirs. The analysis of results of analytical and experimental researches is carried out that allowed to reveal a number of features of shift and pressure of a condition of breeds at their forgery which essentially influence processes of desorption (sorption) of gas.

Keywords **—geoenvironmental engineering,gas evolution, displacement, methane, fracturing, deposit.**

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I. INTRODUCTION

The presence of free gas is a great danger in the development of coal seams and requires special measures that take into account the possibility of entering the mine not only desorbed gas from coal seams and rocks, but also its breakthroughs in the opening of free gas deposits. The "Guide ..." does not contain recommendations for the joint safe development of coal and gas fields. When working out coal seams, the basis of safe measures is the forecast of gas release into the workings (Filatiev, Filatieva & Antoshchenko, 2018). For this reason, its development in the presence of free gas

collectors is an urgent task for the coal industry.In the methodological plan of construction of calculations of the forecast of gas emission there are characteristic lacks. When developing a method of gas evolution from host rocks should take into account the violation and restoration of the natural state after forgery. For this purpose, it is necessary to know the sizes of height of a zone of disorderly collapse of breeds, height of distribution of vertical cracks, duration of processes of shift of breeds, etc.

To date, the following issues related to the formation of man-made cracks remain insufficiently studied:

- features of formation in rocks of zones of various fractures taking into account development of clearing works and consecutive (or other) transition of breeds from one strained condition to another;
- there are no calculation schemes that take into account the magnitude and type of mechanical impact on the layers of rocks in areas with different stress conditions;
- duration of compaction of rocks after forgery;
- calculation scheme for increasing the degassing effect of wells and their extraction of methane, which is not released into the mine;
- change in the properties of coal of adjacent formations and host rocks in the restoration of rock pressure and the presence of gas or water in closed horizontal cavities of the stratification;
- calculation scheme and necessary conditions for the occurrence of through gas pipelines on the day surface.

II. MATERIALS AND METHODS

The purpose of the study is to develop general provisions for the forecast of gas evolution, which would take into account the presence of hydrocarbon gases of industrial importance and their local accumulations, as well as the inflow of desorbed gas from coal and rocks under the influence of mining.

Research objectives. Perform an analysis of the geological characteristics of Donbass as a gas-coal field. Assess the possibility of free hydrocarbon gases entering the mine.

III. RESULTS AND DISCUSSION

Analysis of the results of analytical and experimental studies (Ajruni, 1981a, 1985b; Akimov, 1970; Beseda, 2002; Iofis, 1985; Kasimov, Krivickij & Degtyarev, 1983; Lidin, Ajruni, Bessonov & Smirnov, 1969; Mohov, 1983; Ozerov, 2001; Petrosyan, 1967; Slashchov, Shevchenko, Kurinnyi, Slashchova, & Yalanskyi, 2019; Subbotin, 1984a, 1985b; Vasilyanskij & Kocherga, 1986) has revealed a number of features of the shift and stress of the rocks during their forgery, which significantly affect the processes of desorption (sorption) of gas:

- the zone of chaotic collapse of rocks is (3 ÷ 6) m;
- the zone of through, mutually intersecting cracks in most cases extends to 20 m;
- the duration of compaction of forged rocks in areas of disorderly collapse and through cracks with complete forgery of the earth's surface depends on the ratio of the gravitational component (γH) and the compressive strength of rocks (ε). During the development of anthracite layers at depths (H) of about 300 m, the compaction time ranged from several years to tens of years, and in deep mines - several months;
- the formation of the fracture zone begins in front of the clearing face;
- degassing effect of treatment can affect the height up to 120 m, drilling wells (from the bottom surface) increases this effect up to 250 m;
- the closure of horizontal strata in the restoration of rock pressure can occur in the presence of gas or water, which affects the change in the properties of adjacent formations and host rocks;
- open cracks up to 0.2 m wide were recorded on the earth's surface during the development of anthracite layers at a depth of 80 ÷ 250 m. In the Western Donbass, when working at depths of 135 ÷ 170 m, three layers with a total thickness of 2.0 m crack width reached 0.8 m.

Geological studies in recent years (Anciferov, 2005; Avdeeva, 2004) have shown that, in addition to gas sorbed by coal and rocks, some coal-fired areas have reservoirs containing gas in the free state.

The structural zoning of the Donetsk basin is based on the zonation of the distribution of different types and sizes of folds and rupture faults, taking into account the presence and thickness of the Meso-Cenozoic sedimentary cover. Precambrian crystalline rocks of the northern part of the Azov Sea are connected with the Donetsk basin along the zone of deep faults. Submerged to a considerable depth, they form the foundation of the basin, which appears near the day surface in the Voronezh massif. The following structural zones are clearly distinguished in the basin: central (middle) of large folds; northern small folds with a system of large regional longitudinal thrusts and subordinate medium and small thrusts; southern small folds complicated by discharges of various scales and directions, including transverse discharges and flexures; the western zone of immersion and attenuation of the folds of the Donbass in the direction of the Dnieper-Donetsk basin (Kalmius - Toretskaya and Bakhmutskaya hollows); northern platform monoclinic zone (Starobilsk - Miller); south-western platform monoclinal zone (Novomoskovsk - Petropavlovsk monoclinal).

Industrial deposits of free gas were found in the Kreminna dome of the Lysychansk coal district. Numerous small domes and flexural folds (potential arch traps for hydrocarbon gases) were found in the whole zone of small folds of the Northern Donbass (areas Tomashevsky, Lysychansky, Vovcheyarivsky, Matrosky, Toshkivsky, etc.). A number of large gas-bearing structures have been discovered in the uplift zone along the regional Severodonetsk advance. Mostly gas traps of the Northern Donbass (structural, vault, tectonic or lithologically shielded) were found in the coal-bearing strata of the Middle Carboniferous at depths from 500 ÷ 600 to 1100 m. The reservoir properties of rocks containing coal grades B-F, quite high, especially in coal-bearing strata C_2^6 - C_2^5. The gas reserves of these fields range from 1.5 ÷ 2.0 to 8 ÷ 14 million m3 and can be considered as clusters. Gas reserves at the Pervomaiskaya Anticline and Novoannivska Flexura are 2.2 to 2.7 billion m3 (Anciferov, 2005).

The limit of formation of highly porous reservoirs is the stage of catagenesis corresponding to the metamorphism grades F. Accumulations of free gases from 3.4 to 10 ÷ 26 million m3 (Kokhov structure, Constantinople and Lavrentyev domes) were found in the South-Western Donbass. The high degree of metamorphism of coal substance in comparison with coal of the F brand and low porosity of sandstones does not exclude a possibility of formation of accumulation of gas in crack-porous collectors of other areas of Donbass (Avdeeva, 2004).

In the coal-bearing rocks of Chistyakovo-Snizhnyansky, the eastern part of the Donetsk-Makeyevka and Central districts, accumulations of hydrocarbon gases are possible, confined to fractured zones of tectonic faults or to man-made reservoirs.

From the geological characteristics of Donbass as a gas-coal field it follows that the development of gas-bearing strata containing coal of almost all brands of a number of metamorphism, it is possible to release gas into mine workings from reservoirs with free gas. The presence of such collectors may be due to the following factors:

- occurrence within the minefields of highly porous (up to 15-20%) gas-bearing rocks (mainly sandstones). They are confined to coal seams with coal of small and medium degree of metamorphism (from grades L to F). As the degree of coal metamorphism increases, the porosity of the host rocks decreases, reaching minimum values (up to 1.0%) for areas of anthracite;

- tectonic faults, in the areas of influence of which the properties of rocks and coal, including fractures, change (Slobodyanyuk, 1987). Low-amplitude disturbances are grouped in zones confined to large faults and are their derivatives. As we approach large geological disturbances, the frequency of low-amplitude disturbances increases;

- conducting work in mining and geological conditions that contribute to the emergence of man-made reservoirs. As a rule, their formation occurs above the boundary of the massif (whole) of coal and the produced space of previously worked lavas (Antoshchenko, 1988). Long-term preservation (for several decades) of man-made gas collectors is characteristic of the conditions of anthracite formation (Antoshchenko, & Pavliv, 1988).

In addition to reservoirs with free hydrocarbon gas, a significant amount may be in the sorbed coal or host rocks. The release of sorbed gas is possible only when the balance of natural gas-coal or gas-rock systems that occurs in the area affected by mining. The maximum amount of gas sorbed by coal reaches 50 m3/t, and contained rocks - up to 5 m3/t.

According to the degree of complexity of ensuring safe conditions for the development of coal seams, based on the availability of possible sources of gas, minefields can be classified as follows:

- there are natural collectors of free gas due to the presence of highly porous rocks, tectonic faults and man-made reservoirs formed under the influence of previous mining operations;

- there are no one, two or all possible free gas collectors, but there are geological disturbances;

- there are no collectors of free gas and geological disturbances, and the level of gas evolution in the mine workings, other things being equal, is determined by the natural gas content of host rocks and adjacent coal seams.

The probability of possible gas occurrence from each type of free gas reservoir is different for rocks containing coal seams with different degrees of metamorphism. In the areas of coal seams from grades L to F, one should expect, first of all, the main gas evolution from highly porous host rocks.

Most of these reservoirs are local gas accumulations, but in some cases they can be classified as industrial deposits. The share of possible gas evolution from the considered source in the overall balance of mine workings, other things being equal, will decrease with increasing degree of coal metamorphism. This is due to changes in the physical properties of the host rocks, including a decrease in their porosity and a reduction in the degree of filling the pores with gas.

The influence of tectonic disturbances on the change of physical properties of rocks containing coal seams and the possibility of the appearance of free gas reservoirs must be taken into account in the extraction of coal of all brands.

Geological disturbances, depending on their type, can contribute to the formation of accumulations of free gas or its migration to the earth's surface. Accumulations of gas are possible in the presence of a shielding layer.

Deterioration of reservoir properties of rocks with increasing degree of coal metamorphism leads to an increase in the role of fractured gas reservoirs, which are intensively developing near tectonic faults. As the degree of post-diagenetic transformations of coal and rocks increases, the role of tectonics in the formation of gas microdeposits gradually decreases. There are pitfalls that relate to the operational type. Cracked collectors in this case occur when the redistribution of stresses in the mountain massif during the excavation.

Disturbances near which gas deposits are formed have, as a rule, small amplitude (0.5 ÷ 5.0 m). This is due to the fact that the fractured zones that accompany such disturbances are localized in space, and the surrounding intact deposits serve as a screen for gases. Large disturbances, especially discontinuous, often contribute to the degassing of the stratum. At the same time, their elements of occurrence largely determine the spatial position of both individual low-amplitude disturbances and localization zones. Even in the absence of spatial connection of low-amplitude disturbances with large-amplitude ones, small disturbances are located chaotically in the coal-bearing stratum, and form certain zones, which are the places most prone to the formation of methane deposits.

Without denying the influence of technological factors on the process of crack formation, it should be noted that the local zonation of the spread of

microdeposits in the array is determined to a greater extent by natural causes.

In parallel with the change of fractures in the zones of geological disturbances, the gas permeability of the layers also changes. Depending on the type of geological disturbance, the natural gas permeability of the layer in it may be greater or less than outside the disturbance (Ryzhenko, 1986). Changing the geometric parameters of the strata and rocks causes not only a change in their physical properties, but leads to the formation of zones that differ from the pristine massif of rocks prone to gas-dynamic phenomena. This is confirmed by the results of studies (Ol'hovichenko, Suhorukov & Verhovskij, 1972) that show a parallel change in the thickness of the formation, strength and porosity, the rate of convergence of rocks and the initial rate of gas evolution in the wells.

Direct measurements of the absolute level of gas emissions indicate the impact of rupture violations at a distance of at least 700 m in the plane of the formation. Similar results of the degassing effect of discharges (680 m) were obtained (Brizhanyov, 1982) when determining the gas bearing capacity of the anthracite formation.

IV. CONCLUSIONS

The presence of gas sources in gas and coal fields of Donbass, differing in conditions of geological and man-made formation, as well as forms of physicochemical (or other) gas states in these sources, determines the following important procedure for forecasting gas emissions for a particular minefield:

- the affiliation of the mine field to the structural zoning is established;
- mine field is assessed by the complexity of the tectonic structure;
- given the porosity of rocks, the possible saturation of their free gas is established. The fact of the presence of free gas in these reservoirs is established, as a rule, at the stage of exploration work;
- the possibility of formation of natural and man-made gas traps within the boundaries of the mine field is considered;
- the influence of geological disturbances on increase or decrease of natural gas bearing capacity of coal seams and host rocks is determined;
- quantitative assessment of sources of free and sorbed by coal and rocks gas on the area of the mine field.

Based on this assessment, a conclusion is made about the necessary measures before and during mining.

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