Methane content of coal seams of Karaganda basin

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Abstract. Methods for studying the natural methane content of coal seams during geological exploration are adequately covered, so the main focus when considering them is landing on those features that are characteristic of the Karaganda basin. The method of studying the qualitative composition of gas in the basin establishes a change in the concentration of methane depending on the geological conditions of the bedding, while it is necessary to find the upper boundary of the methane zone, which is defined as the surface, and the concentration of methane is 80%.

1. Introduction
Safe and economical coal mining in the Karaganda basin, as in many mines in the country, depends on the content and distribution of methane in coal seams and rocks, as well as on the quality and degree of accuracy of the prediction of methane-bearing coal seams and mine methane abundance. Therefore, studies of natural methane-bearing and geological factors determining the formation, accumulation and preservation of methane in the coal layer are priority tasks when exploring new mine fields and developing deeper horizons of existing mining enterprises. The need for such studies is due to the high release of methane in the mine workings, which is associated with the use of high-performance equipment, increasing the depth of development and higher methane-bearing coal beds of the Karaganda basin, unlike other basins in the country.

The qualitative characteristic of natural methane content, which prevailed before the adoption of regulatory documents, gave way to a quantitative assessment with a given accuracy of determination. However, the further development of the work is hampered by insufficient knowledge of the factors responsible for the natural methane content of coal seams and rocks, as well as the weak feasibility of some of the adopted methodological provisions.

2. Methods for studying
Methods for studying the natural methane content of coal seams during geological explorations are adequately covered, so the main focus when considering them is landing on those features that are characteristic of the Karaganda basin [1].

During exploration in the basin, the method of study is the qualitative composition of the gas, as well as direct and indirect methods for determining the methane content of coal seams.

The method of studying the qualitative composition of gas in the basin establishes a change in the concentration of methane depending on the geological conditions of the bedding, while it is necessary to find the upper boundary of the methane zone, which is defined as the surface, and the methane concentration is 80%.
The method consists in sampling in a special hermetic vessel from a core raised to the surface with a standard coring projectile or a double coring tube. According to the composition of the gas contained in the sample, the concentration of gas components (methane) at the sampling point is identified.

The simplicity of this method predetermined its wide usage during fieldwork. Currently, the basin accumulated significant material with the nature of changes in the concentration of methane in coal seams.

3. The method of direct determination of methane content of coal seams

The method of direct determination of methane content of coal seams is the main one and is used with the help of a core gas basin with a "bell". The basin uses a type of KG-55 - 2m core gas basin [2].

Interpretation of the results of testing with core gas basins is carried out according to the method [2]. The nature of the increase in methane content with depth is identified according to this method, based on the premise that the ascending increase branch is described by a Langmuir type equation. The processing scheme of the results of testing is reduced to the following operations.

1. Correlation tables of changes in natural gas content \( X \) in a function of sampling depths \( N \) are compiled, for which the number of intervals \( m \) and their optimum value are previously determined depending on the amount of sampling data using the formula:

\[
m_i = 1 + \log \sum n_0
\]

where \( n_0 \) – the number of sampling points.

The optimal value of the length of the intervals (1) is found as a quotient of dividing the difference between the maximum and minimum values of natural gas content (span) by the number of intervals:

\[
R = \frac{X_{\text{max}} - X_{\text{min}}}{m}
\]

When processing gas sampling in the Karaganda basin, the value of the depth interval is generally taken to be 50–100 m, and by natural methane content \(- 2 \text{m}^3/\text{t gm}\).

2. The starting point is selected with the coordinates \( X_1, H_1 \), so that it could correspond to a stable increase in the natural methane content, i.e. met the condition \( 3 \times X_1 > 10 \text{ m}^3/\text{t gm}\).

3. The average values of natural methane content are calculated by depth intervals:

\[
X = \frac{\sum X_i}{n_i}
\]

where \( X_i \) – values of natural gas content in a given depth range, m\(^3\)/t gm; \( n_i \) – the number of samples

4. The actual value of the methane content stage is determined.

\[
a = \frac{H_i - H_1}{X_i - X_1}
\]

5. Assuming that the methane content stage \( a \) varies with depth according to the law of a straight line: \( a = A + BH \), by the least squares method from the equation system can be found the values of the coefficients \( A \) and \( B \):

\[
\begin{align*}
\sum a_i &= B \cdot H_i + n \cdot A \\
\sum a_i \cdot H &= B \cdot \sum H_i^2 + A \cdot \sum H_i
\end{align*}
\]

6. The found values of the coefficients \( A \) and \( B \) are used in determining the coefficients \( c, b \) and \( H_0 \) of the Langmuir equation:

\[
c = \frac{(X_1 \cdot B + 1)^2}{A + B \cdot H_1}
\]
The numerical values of the coefficients are substituted into the equation:

\[ X = \frac{c \cdot (H_i - H_o)}{1 + b \cdot (H_i - H_o)}, \text{ m}^3/\text{t} \]  

and for given depths, the natural methane content of the seams is determined.

The method for determining the methane content of coal seams according to gas surveys data in preparatory mine workings is indirect. Gas surveys were carried out during coal exploration by the Karaganda Polytechnic Institute and during preparatory works in the mines to clarify the data on methane content obtained during the exploration period and to evaluate the degassing efficiency of the Karaganda branch of VostNII.

The technique developed in work [1,3] is used. The initial parameters for calculating the methane content of coal seam are the results of measurements of the total methane consumption passing through the sections of the peak production pickets \( Q_{m1}, Q_{m2}, \ldots, Q_{mi} \) m\(^3\)/day with the coal wall exposure time at the picket level of \( t_1, t_2, \ldots, t_i \) days.

These data, as well as the thickness of the coal mass of the seam \((m)\), the average speed of the progress of development between the pickets \( V_{1пр}, V_{2пр}, \ldots, V_{iпр} \) m/day, allow us to calculate the total outgassing with 1m\(^2\) of coal wall

\[ Q_i = \frac{1}{2} \cdot \left( \frac{Q_{m1}^1}{V_{np1}} + \frac{Q_{m2}^2}{V_{np2}} + \ldots + \frac{Q_{mi}^i}{V_{npi}} \right) \cdot i^3 \]  

If the substantial unevenness of the speed of progress of the development is not fixed, then the measurement is carried out only at the exit from the dead-end development. In this case

\[ Q_i = \frac{Q_m}{2 \cdot m \cdot V_{cp}^m} \]  

It is known that

\[ Q_t = \frac{q_0}{n} \cdot t^n \]  

where \( q_0 \) – the initial intensity of methane release by the end of the first day of exposure of the coal wall, m\(^3\)/m\(^2\) day; \( n \) – coefficient characterizing the rate of reduction of methane release over time.

The relatively high accuracy of the determination of methane content compared with the method of core and gas basins promoted the introduction of gas surveys into the practice of work. Currently, the method of gas surveys in the mine workings is used in the exploration of all the mine fields of the basin, where there are necessary conditions for their conduct.

Determining the position of the depth of the upper boundary of the methane gas zone with the required accuracy is one of the main tasks when studying the natural gas content of coal seams. For detailed exploration of a site (deposit), it is necessary to identify its position with maximum accuracy. This problem is solved, basically, by testing coal seams with hermetic cups in the proposed depth range of the transition to the methane gas zone. However, a number of complications in processing the results of testing significantly reduces the reliability of the method and makes it difficult to solve the problem. As a rule, it is not possible to take samples with a methane concentration of 80%. The obtained values of methane concentration in samples vary considerably at the same depth of sampling.
This circumstance often makes linear interpolation impossible when determining the depth of the upper boundary of methane gases.

At the same time, there is often an urgent need to assess the depth of the methane gas zone of the sites where previously testing for methane content for some reason was not carried out or was not carried out to an insufficient extent. In this case, a situation arises in which the total exploration of the site (deposit) is satisfactory, and data on the nature of the occurrence of methane gas zones are missing or do not meet modern requirements. This situation is observed, in particular, with the involvement of lower layers of the Karaganda Formation in the Industrial site of the Karaganda basin.

To solve these on the basis of extensive material on sampling of hermetic cups and core gas basins of coal seams in the zone of demethanization and methane gases, an attempt was made to identify the main geological factors that determined the formation of a zone of gas weathering in the basin, and to assess the quantitative force of their influence. Such an approach will allow, in the first approximation, to calculate the graph-analytical depth of the upper boundary of the methane gas zone for any part of the basin in the known general geological situation.

4. Summary
The role of various geological factors in the formation of the demethanization zone is considered in a number of works [4–9]. The main factors determining the depth of distribution of the gas weathering zone are noted - the history of the geological development of the basin, the angle of incidence of the coal-bearing strata, the presence, thickness and nature of the overburden hydrogeological conditions.

The history of geological development is determined by the nature of the orogenic phases of folding, the oscillating movements of the main stages of erosion and the subsequent demethanization of coal-bearing sediments with positive signs of crustal movement, as a rule, denudation and demetanization are associated, and the coal-bearing strata overlapping by cover sediments slowing demethanization or inhibiting it is associated with negative signs.

When methane migrates to the ground surface, mainly on coal seams, the angle of incidence determines the length of its movement. In connection with this, steeply dipping seams, with other things being equal, demethanize to a greater depth vertically than flat ones.

Cover sediments formed during the majority of negative forms of crustal movement, depending on the thickness, lithological composition, facies consistency and the time of their accumulation affect the distribution of methane in the coal-bearing strata in different ways. Depending on the ratio of these factors, the overlapping of the coal-bearing strata with younger sediments causes a slowdown or almost complete stoppage of methane migration. This often leads to the recovery of methane content in previously demethanized coal seams and in coal-bearing sediments.

Circulating underground water degasses the coal-bearing strata. It is noted that the upper boundary of the methane zone is confined to the bottom of the zone of active water exchange.

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