

## SUMMARY

of dissertation for academic degree of Doctor of Philosophy (PhD)  
in educational program 8D07201 – Geology and Exploration of Mineral Deposits

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### THE STUDY OF THE MINING-GEOLOGICAL CONDITIONS OF THE D<sub>6</sub> BANK'S OCCURENCE ON ITS METHANE CONTENT

**The relevance of the problem.** The development program "Kazakhstan 2050" provides for the development of the coal industry as the basis of energy security and stability of the production of metallurgical raw materials.

The main goal of the program "Kazakhstan 2050" is to create a welfare society based on a strong state, a developed economy based on the principles of profitability and competitiveness.

The prospects for the development of coal mining are associated with the fact that coal is the main energy raw material and raw material for the production of coke, special coke, and carbonaceous reducing agents used in the slag-free production of metals, for example, silicon.

Coal deposits represent a large resource base of Kazakhstan with the ability to export coal and its processed products. These factors are determined by its relatively low price among other energy source materials.

An increase in the depth of development in the Karaganda coal basin leads to an increase in the loads on the coal face (from 2000 to 5000 t/day), while the volume of gas can range from 40-50 to 120-160 m<sup>3</sup>. Early extraction of methane from coal seams is the basis for the integrated development of coal and gas deposits, reducing natural gas content to the required values and, as a result, reducing the absolute gas content of coal faces, and increasing the productivity of layer degassing wells by 3 or more times.

The Karaganda coal basin is one of the most highly gas-bearing among the coal-producing countries of the world. Its coal seams at a depth of up to 1800 m contain up to 4.0 trillion m<sup>3</sup> of methane.

The work of coal mines in the Karaganda basin at the present stage is characterized by a significant complication of mining-geological and mining conditions. An increase in the gas content of coal seams, an increase in mountain pressure are especially significant in the development of powerful shallow formations, such as the D<sub>6</sub> (Kassinsky) formation, which gives the main share in coal production in the basin.

The domestic scientists M.A.Yermekov, M.V.Schmidt, R.R. Khodjaev, J.M. Biryukov, S. K.Baimukhametov, V.F.Demin, S.B.Aliev, V.S.Portnov, E.N.Filimonov, R.K. Atygaev, R.I. Gabaidullin, S.T. Asainov engaged successfully studies of the problem of coal seams' gas content of Karaganda basin, increased gas emission in the zones of geological disturbances, their forecasting and impact on the development of high-gas-bearing seams. The great contribution to the scientific substantiation of safe mining of outburst-risk reservoirs and prediction of disturbances made by Ukrainian scientists V.A. Antsiferov, G.G.

Pivnyak, S.A.Vyzhva, T.A.Vasilenko, L.S.Volpova, I.A.Ocheretenko, V.V.Troshchenko, Russian scientists A.T. Airuni, A.D.Alexeev, A.A.Skochinsky, G.D.Lidin, S.B.Slástunov, K.S.Kolikov and many others.

Currently, the gas factor is the main deterrent that prevents the stable operation of the working area that working out the D<sub>6</sub> formation with a daily load of 5000 tons/day or more. Safe and high-performance coal mining depends on the content and distribution of methane in coal seams and adjacent strata, as well as on the quality and degree of reliability of the forecast of methane content of coal seams and methane abundance of working areas. Therefore, studies of geological factors determining the gas content of coal seams, affecting the efficiency of mining promising mining sites, are very relevant.

The dissertation is based on actual and forecast materials reflecting the mining and geological conditions of the development of coal seams, as well as the results of scientific research obtained during doctoral studies.

As part of study, the actual values of the methane content of the D<sub>6</sub> coal seam were obtained according to geological exploration data, as well as during cleaning and preparatory work, as well as by direct measurement of the methane content of the D<sub>6</sub> formation at the mines of the Tentek district with the linking of mining and geological conditions of occurrence. The results of using the developed methods for predicting previously undetected geological disturbances are presented, based on the numerical calculation of increased methane release from coal in the zones of violations, according to the criterion for assessing the geological factors of methane release of coal from the D<sub>6</sub> formation on the efficiency of mining operations during the preparation and development of working areas along the D<sub>6</sub> formation.

**Subject of research.** Powerful flat bed D<sub>6</sub>, which gives the main share in the coal production of mines Tentek district.

**The purpose is** improvement of theoretical methods for predicting geological disturbances to establish the zoning of increased methane emission and development of measures to improve mining efficiency in the conditions of the D<sub>6</sub> formation of the mines Kazakhstanskaya and V.A. Lenin.

**The idea** of the work is to develop a methodology for calculating the natural methane content of the D<sub>6</sub> formation by the methane abundance of mining sites, forecasting geological disturbances of the carboniferous massif and zones of increased methane release based on the theory of elasticity, limiting critical stresses, assessing the impact of these factors on the efficiency of mining sites.

**Research objectives:**

1. Analysis of mining and geological conditions of occurrence of coal seams of the Tentek coal-bearing region;
2. Study of geological factors that determine the methane content of the coal seam and the nature of its distribution;

3. Analysis of the existing system of management of gas emission during mining operations in conditions of high-gas-bearing bed  $D_6$  of mines "Kazakhstan" and in mine named by V.I. Lenin;

4. Study of the regularity of manifestation of increased methane content associated with the structure of the coal seam;

5. Development of a methodology for predicting undetected fault tectonic faults in the field of the mine named by V.I. Lenin mine, conducting experimental studies on a numerical mathematical model to confirm the prediction of faults;

6. Development of methods for calculating the methane emission from the coal mass in areas of geological faults;

7. Analysis of the effectiveness of mining faces depending on the methane content of the seam and in the presence of geological disturbances, including sudden fractures in the seam soil.

**Research methods.** Methods of analysis and interpretation of geological information about the structure, conditions of bedding of coal seams; methods of statistical processing and correlation analysis of the results of field and experimental studies of methane content of coal seams; methods of fuzzy cluster data analysis; analytical and numerical methods applied to the theories of elasticity and strength; use of software for scientific and engineering research in the field of mining and research the stressed state of the coal massif.

**The main scientific provisions** in the dissertation are as follows:

- shallow-amplitude disturbances and fracturing of the coal-rock massif are mostly caused by the hypsometry of the coal seams and host rocks;

- critical stress components, calculated from geological exploration data, determine the dislocation of unrevealed small-amplitude disturbances in the mine field;

- increased methane emission is characterized by the fine-fractional structure of the coal substance in disturbances and can be predicted when designing mining operations.

**The scientific novelty** of the research work is as follows:

1. The relationship of methane content of coal bed  $D_6$  with changes in the physical and mechanical properties of the coal seam, structural and textural factors and layer hypsometry was established.

2. A physical model has been created describing the patterns of changes in methane abundance associated with changes in the size of coal particles in areas of technological disturbances, changes in the stress-strain state during mining operations.

3. Methodological bases for calculating the methane content of a coal seam by methane abundance have been developed, taking into account the influence of geological factors, including geological disturbances, based on the use of cluster analysis methods and fuzzy sets to assess whether critical stresses belong to zones of geological disturbances and abrupt changes in the hypsometry of the coal seam.

**The theoretical and practical significance** of the work consists in the development of a dimensionless criterion for assessing the danger of sudden fractures of the reservoir soil based on its methane-bearing capacity of the reservoir and the power of the protective layer, the width of the coal face; a method for determining the curvature of the formation's surface based on the data of an irregular line of exploration wells and the physical and mechanical properties of the host rocks, which makes it possible to predict zones of tectonic curvature (deformations) for formation conditions and, based on the calculation of stresses acting during deformation, to determine the locations of possible discontinuous tectonic disturbances, which increases the safety and productivity of mining layer.

**The scientific significance of the work** consists in the development of a method for determining the curvature of the formation surface based on the data of an irregular line of exploration wells and the physical and mechanical properties of the host rocks, to predict zones of tectonic curvature (deformations) for the formation conditions.

**The practical value of the results of the work** consists in providing research and project organizations and subject specialists with a tested tool for predictive determination of the location of geological disturbances in new sections of the mine field.

**Personal contribution of the author.** The work was carried out by the author personally, including the set of goals and objectives consists in the scientific substantiation of the application of the method of multifactor analysis in the construction of the isoline of the natural gas content of the D<sub>6</sub> formation, which can be used in the design to calculate the expected gas content of working areas, the efficiency of mining operations; the technology of preventing sudden destruction of soil rocks (SDSR) is proposed, which consists in carrying out advanced mining of protective layers, measures to reduce the ability to delaminate the coals of the lower layer, changing the technology of coal extraction, reducing the methane content of the developed formation using point-interval hydraulic fracturing; forecast of dislocation of geological disturbances not detected at the stage of geological exploration; recommendations for assessing the methane content of the formation on the methane abundance of the coal face were made; experimental studies have been carried out in joint publications, the author has given a theoretical justification, laboratory and industrial tests have been carried out, a physical model of the processing and calculation methodology has been substantiated.

**The reliability and justification** of scientific statements, conclusions and recommendations are confirmed by:

- the correct and purposeful formulation of research tasks, the reliability of the field and experimental data used by the use of modern methods of data processing and numerical modeling;

- the degree of justification and reliability of scientific results and conclusions formulated in the work, confirmed by the consistency of all results obtained both by calculation and experimentally.

- the evaluation of research results at international conferences, discussions at seminars of the G&ME Department of the Abylkas Saginov Karaganda Technical University and the Scientific and Technical Council of the Navoi State Mining Institute (Uzbekistan), recommendations for their implementation in production were received;

- the acceptance of the act on the introduction No. 01-11/92 dated 13.05.2022 of the results of scientific research on the dissertation in the practical activities of the SIC "GeoMark" LLP to improve the efficiency of mining operations during the development of the high-gas-bearing layer D<sub>6</sub> in the mines of the Karaganda basin and the prevention of gas dynamic phenomena.

- a certificate of introduction (No.2-953 dated 22.06.2022) of the research work results on the forecast of new geological disturbances, undetected during exploration of the field, and their locations; a quantitative method for determining the increased absolute methane content in excavation of D<sub>6</sub> seam in the zones of forecasted disturbances; criteria for assessing the influence of mining-geological and technological factors on the mining efficiency, which allow to make more informed technical decisions when designing mining operations in mine named by V.I. Lenin.

The scientific work is written on the basis of the results of studies obtained using laboratory equipment to determine the gas content of coal seams, in the "Specshahtomontazhdegazatsiya" CD JSC AMT, equipped with equipment of the German company DMT and using its selection and sample preparation technique. The work contains a set of new scientific results having internal unity and showing the personal contribution of the author to the development of national science.

**Implementation of work.** The main conclusions and recommendations presented in the doctoral dissertation are recommended in the development of high-gas-bearing coal seams in zones of tectonic disturbances in 9 printed articles, 4 reports at international conferences, 2 patents, 3 certificates of state registration of rights to objects of copyright were received.

**Approbation of the work.** The key provisions of the dissertation work were presented at an international symposium and conferences: XIX International Scientific Symposium named after Academician M.A. Usov of students and young scientists, dedicated to the 75th anniversary of Victory in the Great Patriotic War "Problems of geology and mineral resources development", (Tomsk, 2020); International Scientific and Practical Conference "Integration of Science, education and production – the basis for implementation of the national Plan" (Saginovsky Readings No. 13) (Karaganda, 2018); XVI XVI International Forum of Students and Young Scientists "Topical Issues of Rational Use of Natural Resources" (St. Petersburg, 2020).

The Eurasian patent "Method of quality control of solid fuel" (co-authored) (Appendix I) was obtained.

The patent of the Republic of Kazakhstan "Method of quality control of coals of complex composition" (co-authored) (Appendix K).

There are 4 intellectual property certificates "Studying the factors affecting the outburst hazard of the D<sub>6</sub> coal seam", "Forecast of natural methane content in

the development of coal seams", "Gas content of the D<sub>6</sub> coal seam", "On establishing the degree of influence of geological factors on the methane abundance of working areas" (co-authored) (Appendix L).

**Structure of the work.** The dissertation work consists of an introduction, 4 sections and conclusions, presented on 115 pages of the printed text, contains 48 figures, 18 tables, the list of 115 references, 11 appendices.

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