INSTITUTE OF COMPREHENSIVE EXPLOITATION OF MINERAL RESOURCES
Russian Academy of Sciences

Centre for Coal Mine Methane in Russia

Background, Objectives and Activities

Director ICEMR RAS
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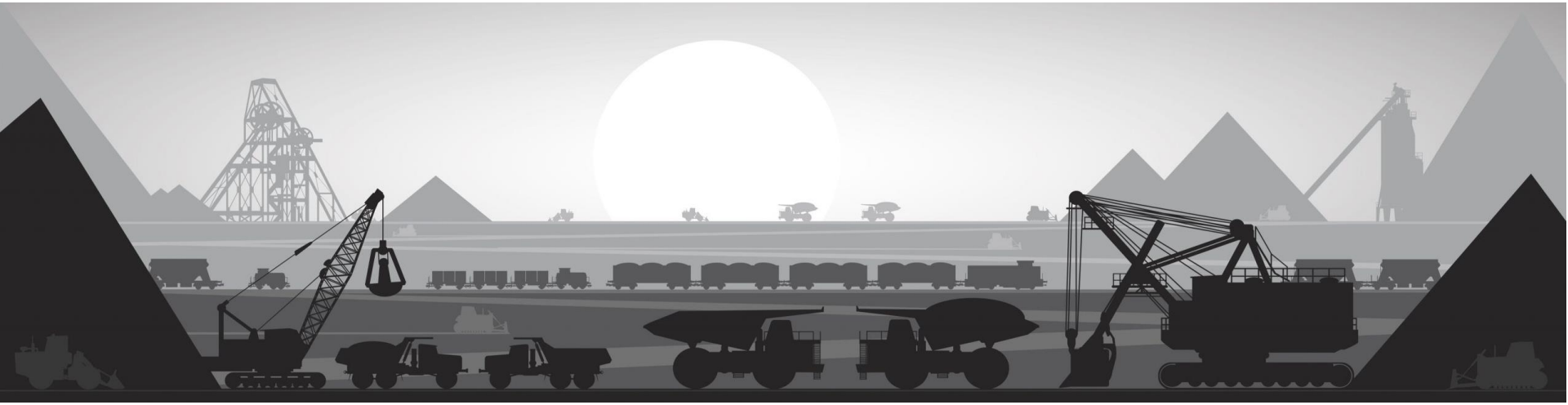


Genève, Switzerland

3rd March 2021

Location of coal basins in Russia

The methane resource estimate for depth in 1800-2000 m.

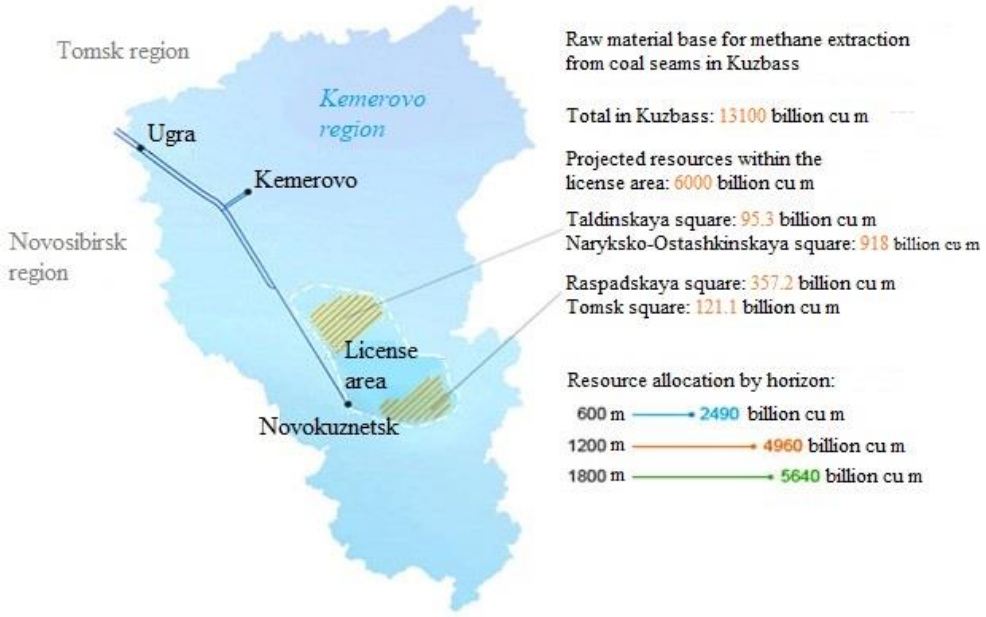
Many methane coal deposits in our country can be classified as medium and large. And some such as "Taldinskoye" and "Naryksko-Ostashkinskoye" (Kuzbass), are unique deposits. The resource base of The mining projects is base on resources of '"Naryksko-Ostashkovskoe" field and "Tutunska" area. The total reserves of the projects for C1 category - 39.3 billion m3, C2 category -210.2 billion m3, of which the "Naryksko-Ostashkinskoye" field for 34.5 billion m3 and 130.8 billion m3, respectively. Resources are estimated at 5.7 trillion m3, including 235 billion m3 at the "Naryksko-Ostashkinskoye" field.

Methane deposits in Kuzbass

The highest density of coal methane resources

Resources of the Kuzbass regions for large-scale methane production (outside the mine fields) as an independent mineral:

- ”Yerunakovsky” - 2935.0 billion m^3,
- “Tom-Usinsk” - 1403 billion m^3,
- ”Kondomsky” - 967.3 billion m^3,
- “Tersinsky” - 956 billion m^3,
- “Bunguro-Chumyshsky" - 758.9 billion m^3,
- “Kemerovo” - 710.3 billion m^3,



The highest density of coal methane resources (from 2.0 to 1.0 billion m^3/km^2) are characterized by: ”Erunakovskij”, “Tom'-Usinskij”, “Bunguro-Chumyshskij”, ”Prokop'evsko-Kiselevskij”, “Aralichevskij”, “Kondomskij”, “Mrasskij” and “Titovskij” geological and industrial areas of Kuzbass. The density of coalbed methane resources within the boundaries of the estimate to the depth of - 1500 m is on average 716 billion m^3/km^2 in Kuzbass.

Methane resources of gas-rich mines in Russia

Application of degassing

Mine	Industrial coal reserves, million tons	Methane extraction coefficient by means of degassing and gas extraction, fractions of units.	Methane resources, million m^3	
			Seams in progress (geological resources of methane in industrial coal reserves)	Seams complex (geotechnological resources of methane)
Vorkuta deposit				
Severnaya	88,7	0,62	1782,9	3228,7
Ayach-YAta	75,4	0,34	1017,9	5293,1
Vorkutinskaya	47,1	0,53	975,0	2623,5
Komsomol'skaya	72,4	0,43	1505,9	4141,3
Zapolyarnaya	62,0	0,25/ 0,40	1128,4	2957,4
Vorgashorskaya	101,6	0,15/ 0,30	1432,6	843,3
Total:	447,2		7842,7	19087,3
Кузнецкий бассейн				
Named after S. M. Kirov	20,6	0,18/ 0,30	306,9	208,1
Named after November 7	33,8	0,1/ 0,30	466,4	395,5
Komsomolec	76,4	0,64	1283,5	2544,1
Polysaevskaya	54,7	0,8	913,5	1203,4
Oktyabr'skaya	106,0	0,46	1759,6	2809,0
Chertinskiya	13,3	0,6	247,4	637,1
Named after Voroshilov (No. 5/6)	16,8	-/ 0,30	267,1	787,9
Esaul'skaya	112,9	0,03/ 0,30	1637,0	2608,0
Abashevskaya	129,9	0,58	2727,9	3221,5
Yubilejnaya	83,5	0,34	1235,8	926,8
Tomskaya	85,8	0,03/ 0,20	2170,7	2917,2
Osinnikovskaya	127,1	0,13/ 0,30	1385,4	3622,3
Tajzhina	45,1	0,22/ 0,30	464,5	1231,2
Alardinskaya	197,5	0,01/ 0,20	3318,0	3258,7
Raspadskaya	386,4	0,05/ 0,20	6375,6	3284,4
Named after V. I. Lenin	38,6	0,1/ 0,20	752,7	482,5
Total:	1528,4		25312,0	30137,7
Total: (for 22 mines)	1975,6		33154,7	49225,0

Main purposes and objectives

Non-profit partnership "Center for research of best practices in the extraction and use of coal mine methane "

- Research and development for increasing the extraction of coal mine methane by degassing at all stages of the life cycle of a coal-methane field - before the opening of the field, during its industrial extraction, after the completion of the field development;
- Development of methods and tools for extracting methane-conditioned gas-air mixtures suitable for utilization, including in gas-piston / gas-turbine engine installations that generate electric and thermal energy for the needs of mining enterprises;
- Development of methods and tools for increasing the use of methane captured in mines in the regional industry and housing;
- Creating conditions for reducing the amount of coal methane released into the atmosphere;
- Development of methods and means for cleaning CMM, extracting methane from it and producing LNG or compressed methane as a commercial product;
- Research and organizational activities for forming a new resource-producing industry of the Russian Federation.

Research and development activities

- Analysis and research of CMM deposits;
- Creating a map of CMM deposits of the Russian Federation;
- Creation of a digital models of a coal-methane deposit;
- Development of domestic technical tools of CMM extraction;
- Development of methods and tools for intensifying the extraction of CMM;
- Development and feasibility study of the technology of CMM;
- Development of technical tools for processing CMM into LNG and compressed methane;
- Development of technical tools for the use of LNG.

Production and industrial activities

- Creation of a pilot landfill (technical complex) for experimental and industrial development of CMM extraction technologies, intensification of CMM extraction and processing processes;
- Creation of a pilot plant of CMM and the production of LNG;
- Creation of technical tools for accounting, storage and transportation of LNG;
- Creation and / or adaptation of technical tools for the production of electric and thermal energy using CMM as fuel;
- Creation of a pilot complex of motor vehicles (quarry transport) using LNG as fuel;
- Working out the principles of using LNG/compressed CMM in housing.

Structure and functioning

Non-profit partnership "Center for research of best practices in the extraction and use of coal mine methane "

- "Center for research of best practices in the extraction and use of coal mine methane" is Non-profit partnership of:
  - ICEMR RAS
  - JSC «SUEK»
  - EVRAZ
  - Gazprom Dobycha Kuznetsk, LLC
  - National University of Science and Technology MISIS;
  - JSC "NC VostNII"

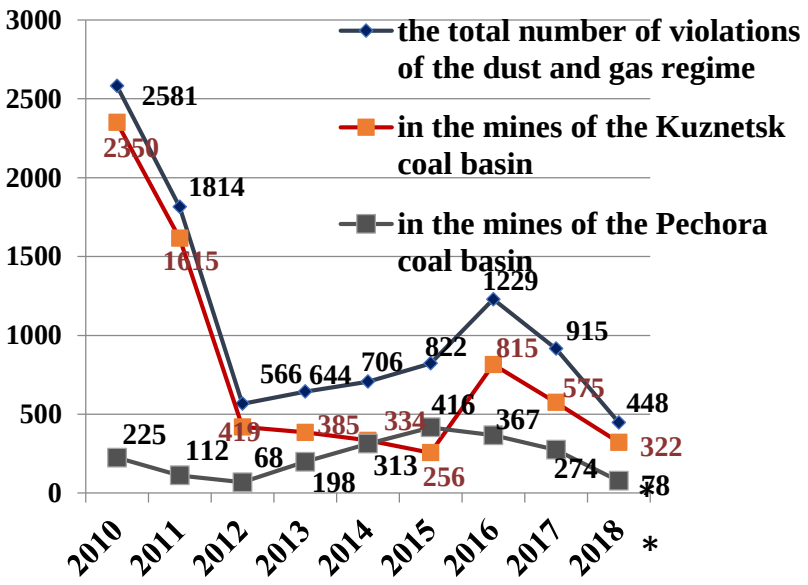
- The center's activities are carried out in accordance with the Strategic Research Plan, State Tasks and Projects, Programs of the Russian Academy of Sciences, Charters of the founding organizations, orders and instructions of the Director of the NP.

- The center carries out domestic and international scientific-technical cooperation with all types of organizations, ministries and departments, organizations and institutions of the Russian Academy of Sciences, Committee on sustainable energy of Economic Commission for Europe, Group of Experts on Coal Mine Methane, in other research and educational centers in Russia and abroad, regardless of legal status.

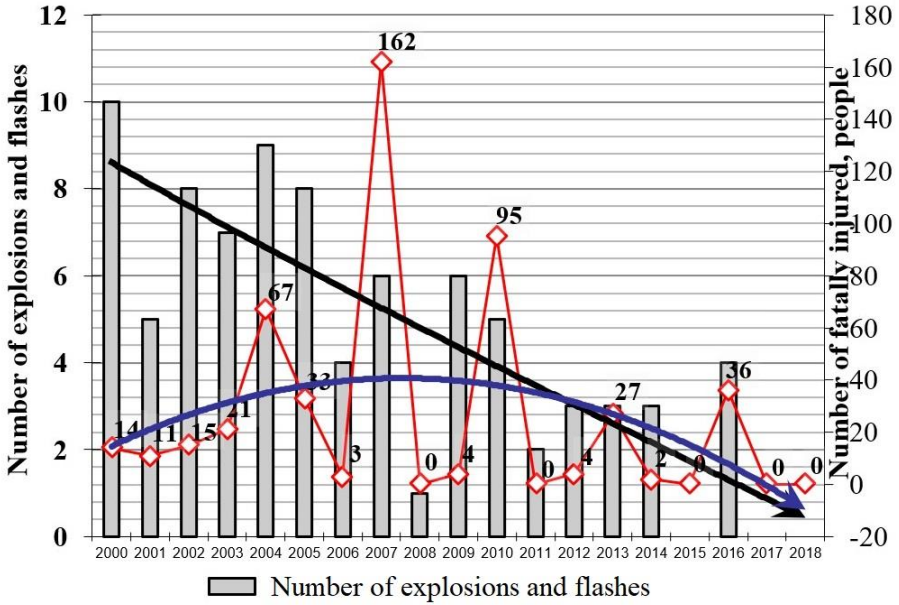
Relevance

State of industrial safety

Dynamics of violations of the dust and gas rules for the period from 2010 to 2018 (1st half of the year)



Dynamics of gas and coal dust explosions and fatal injuries in the coal industry and the polynomial trend line



XXI - is a century of major accidents

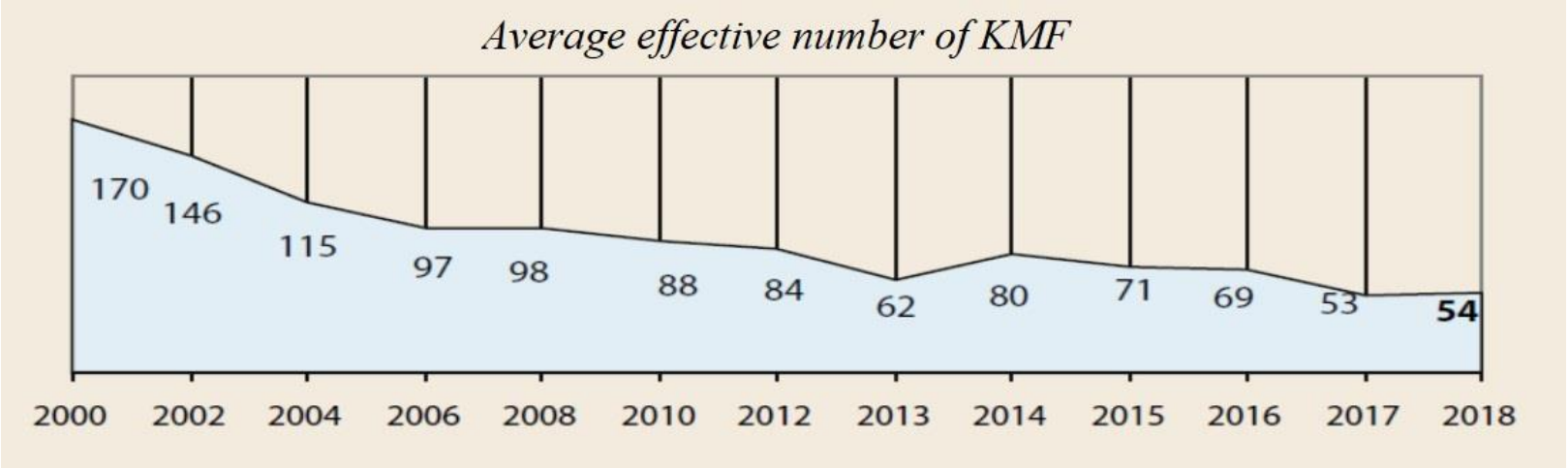
Coal mining industry

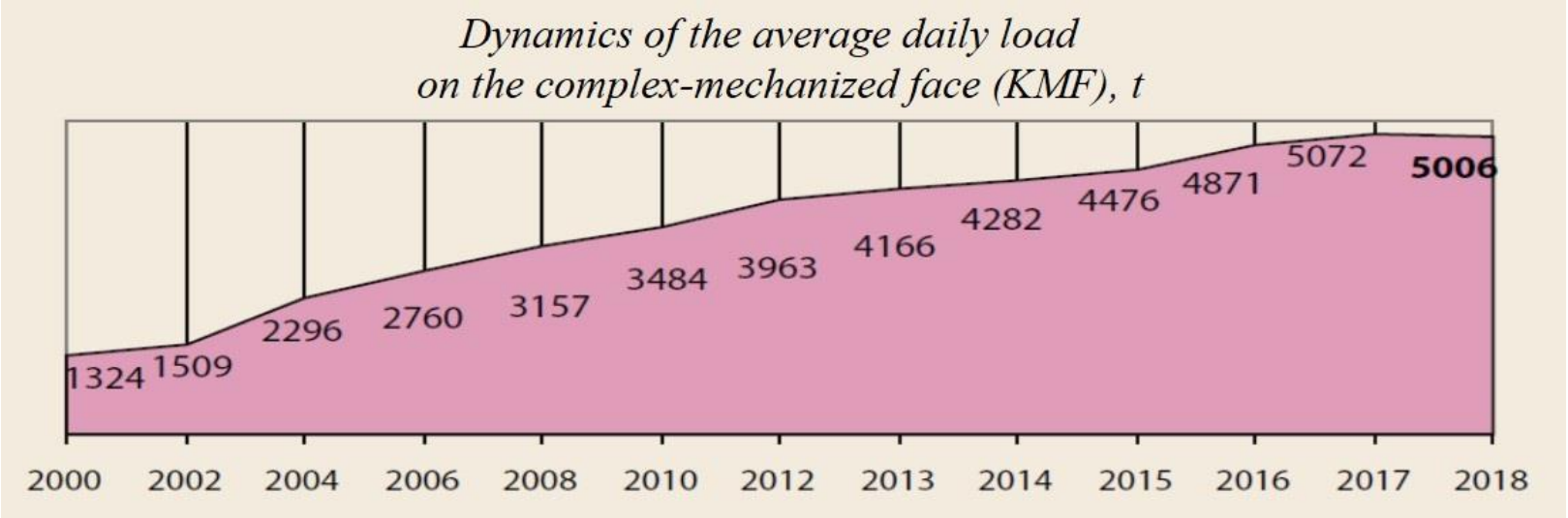
In the period from 2000 to 2016, 9 major accidents occurred at the mines of the Kuznetsk and Pechora coal basins, as a result of which 385 miners were killed

Year	Mine	Cause of the accident	The number of deaths
2007	"Ul'yanovskaya"	Gas explosion	110
2007	"Yubilejnaya"	Gas explosion	38
2010	"Raspadskaya"	Gas explosion	91
2016	"Severnaya"	Gas explosion	36

Relevance

The growth of coal mining





Research

Objectives

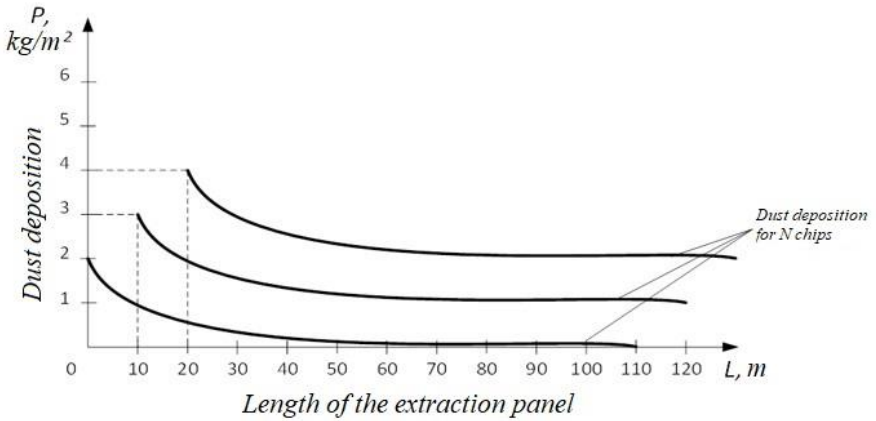
Research of the influence of the dustiness of the mine atmosphere and dust deposition on the safety of the operating modes of high-performance excavation sites when using ventilation schemes with the removal of methane through the worked space.

The main objective of the research is the creation of fundamentals of non-accidental operation of mining industry in the conditions of uncertainty associated with the geological structure and physical properties of rocks, the processes of redistribution of the load allocation, the mass transfer and local accumulations of fluids and gases that determine the composition and parameters of the mine atmosphere, the hydrodynamic mode of groundwater, the topology of mines, modes of ventilation, the formation of the empty space and the change in the properties of the overlying rock layers during the formation of the displacement muld during the high-intensity development of solid mineral deposits

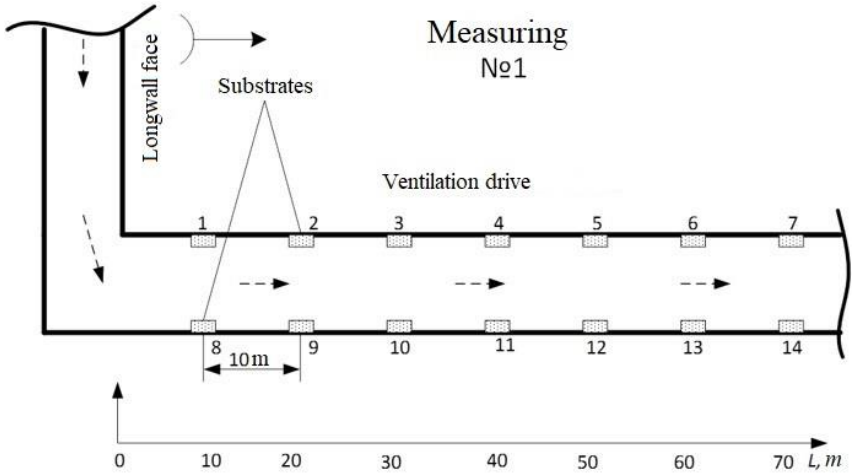
Research

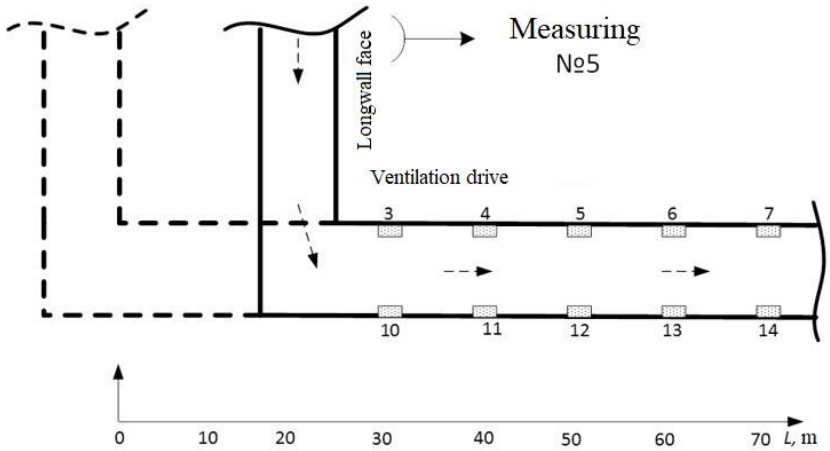
Selection, mass transfer and the formation of local clusters of gas and dust in mines, mined-out space and man-made broken the rocks

Dependence of the intensity of dust deposition in the ventilation shaft, on the change in the length of the excavation column



Schemes of conducting mine experiments on measuring dust deposition in a mine development

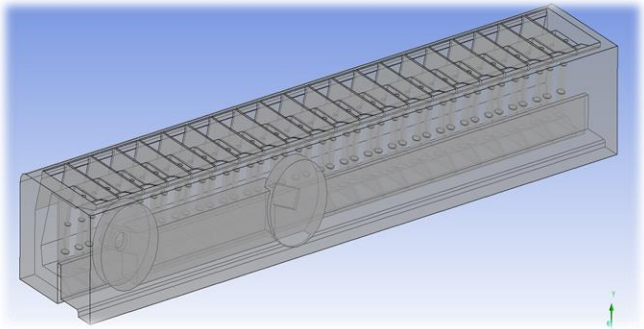


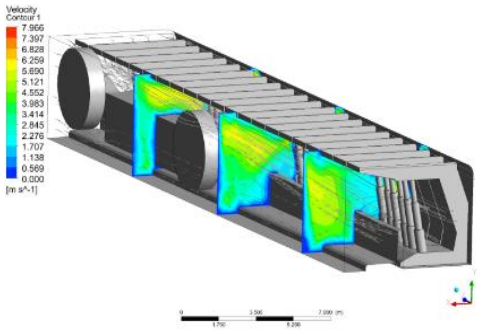


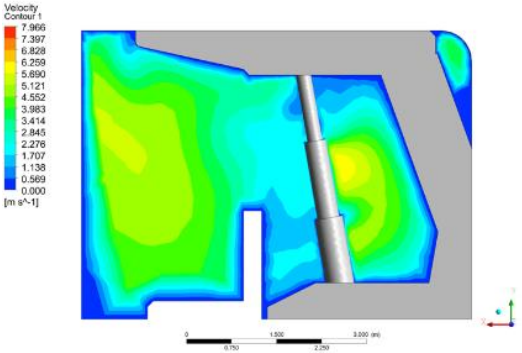
Research

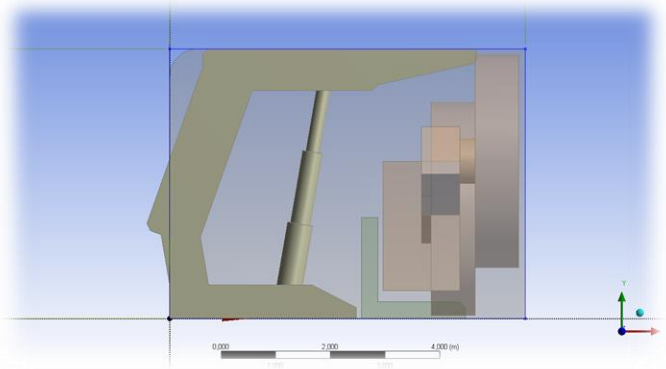
Modeling of dust generation and dust transfer

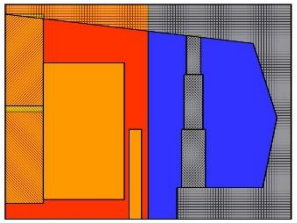
For the first time, the regularities of the redistribution of dust-gas-kinetic parameters of the mine atmosphere in the space of a high-performance face are revealed.











- Maximally dusty area of the longwall face
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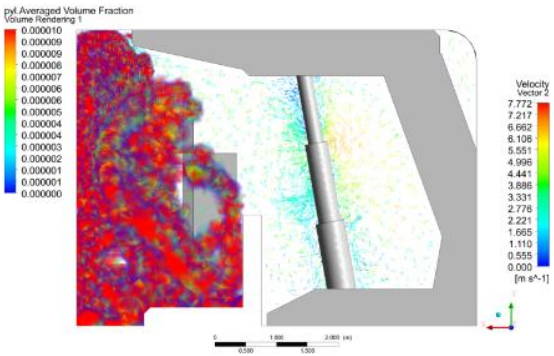
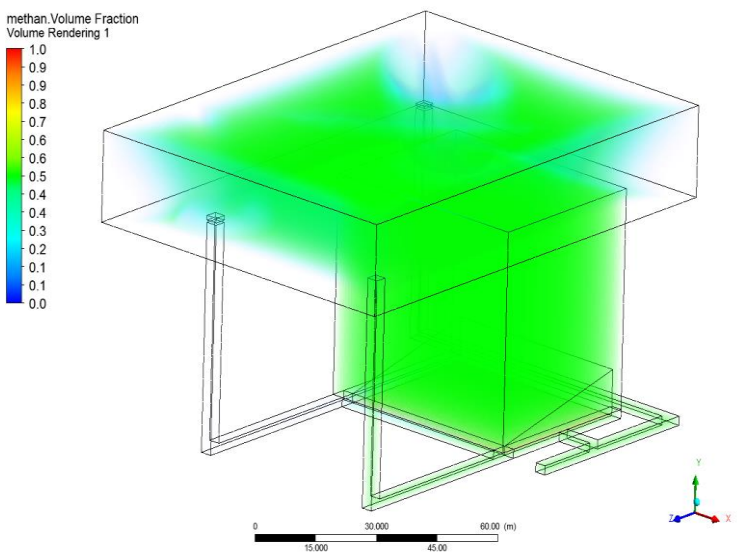


Results of research

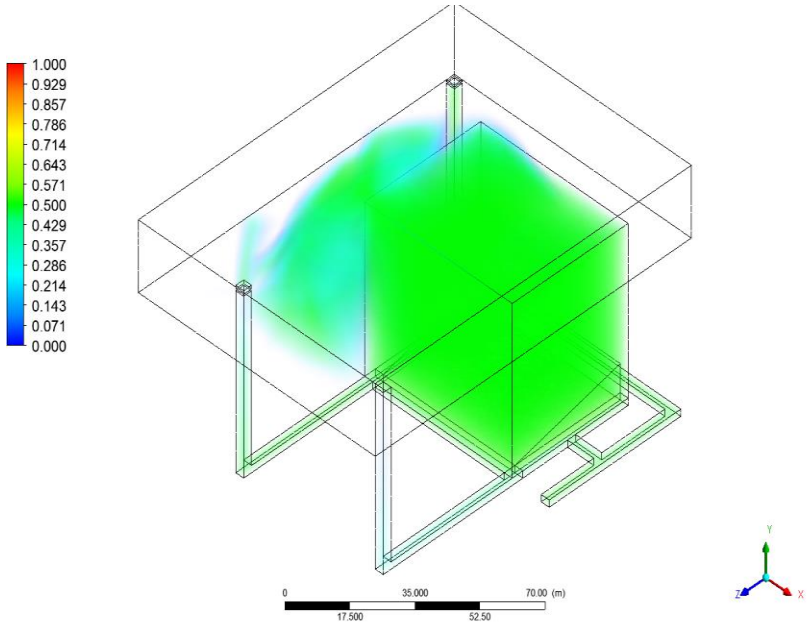
Applications of injection and suction schemes for ventilation of dredged areas for methane release during operations

For the first time, the regularities of separation, mass transfer and formation of local accumulations in the system adjacent mine workings – face – developed space – gas extraction well for injection and suction ventilation schemes are revealed

Injection method of ventilation with the use of removal of methane-air mixture through the empty space



The suction method of ventilation



Modelling

Methane inflows into the mine atmosphere of the face, taking into account the dynamics of the formation of the empty space, degassing and ventilation of mine.

- In the current conditions of high-performance mines and a sharp increase in the rate of movement of mine workings, the length and production capacity of faces, the geodynamic activity of rock massifs and the risks of dangerous, including catastrophic gas-dynamic phenomena, significantly increase.

- With the increase in the depth of mining operations, the risk of gas-dynamic phenomena increases, and an increase in natural gas content and rock pressure has a significant impact. At the same time, both in Russia and abroad, there is almost no sufficient experience of modern high-performance mines at great depths when working out highly gas-bearing, tectonically disturbed coal deposits.

- The forecast of the gas content of mine workings is ambiguous due to the complexity of accounting for a large number of complex interacting factors.

- Accidents at coal mines of the Russian Federation in the XXI century, which had a catastrophic nature, occurred due to explosions of methane gas and coal dust. Therefore, research on the development of the theory of multiphase geo - dynamic processes in gas-saturated coal anthropogenic mutable array to identify conditions and the occurrence of such phenomena is very urgent.

Purpose of research

- The main goal of the planned research is to develop the theory of multiphase geo - and gas-dynamic processes in a technogenically variable gas-saturated coal-rock massif.

- The work is aimed at solving a fundamental scientific problem: - to study the mechanisms of nonlinear geomechanical, gas-and hydrodynamic processes occurring in a technogenically variable coal seam and host rocks and to create geomechanical and filtration models describing the formation of gas reservoirs and methane mass transfer in a rock mass during the extraction of few seams.

- As a result of the conducted studies, the regularities of deformation and destruction of coal seams and the host rock mass, the regularities of methane gas recovery by coal under changing external thermodynamic and physico-mechanical conditions in both quasi-static and dynamic modes will be obtained.

- It is planned to develop a conceptual model of the deformation of the overlying rock mass, the day surface and the developed space. On its basis, geomechanics problems will be formulated for mountain massifs with extended workings, and general analytical and numerical solutions will be constructed that reflect the main technological schemes for the development of the empty space.

Results of research

Modeling of methane inflows into the mine atmosphere of the face, taking into account the dynamics of the formation of the worked space, degassing and ventilation of mine workings.

- Construction of a model of the steady-state filtration motion of liquid and gas in a coal seam relative to a moving free surface.

- **Res**-Model of mass transfer of water and methane in the marginal part of the coal seam, taking into account the progress of the face.

- Development of a microstructural model of methane desorption and filtration from a deformable coal seam.

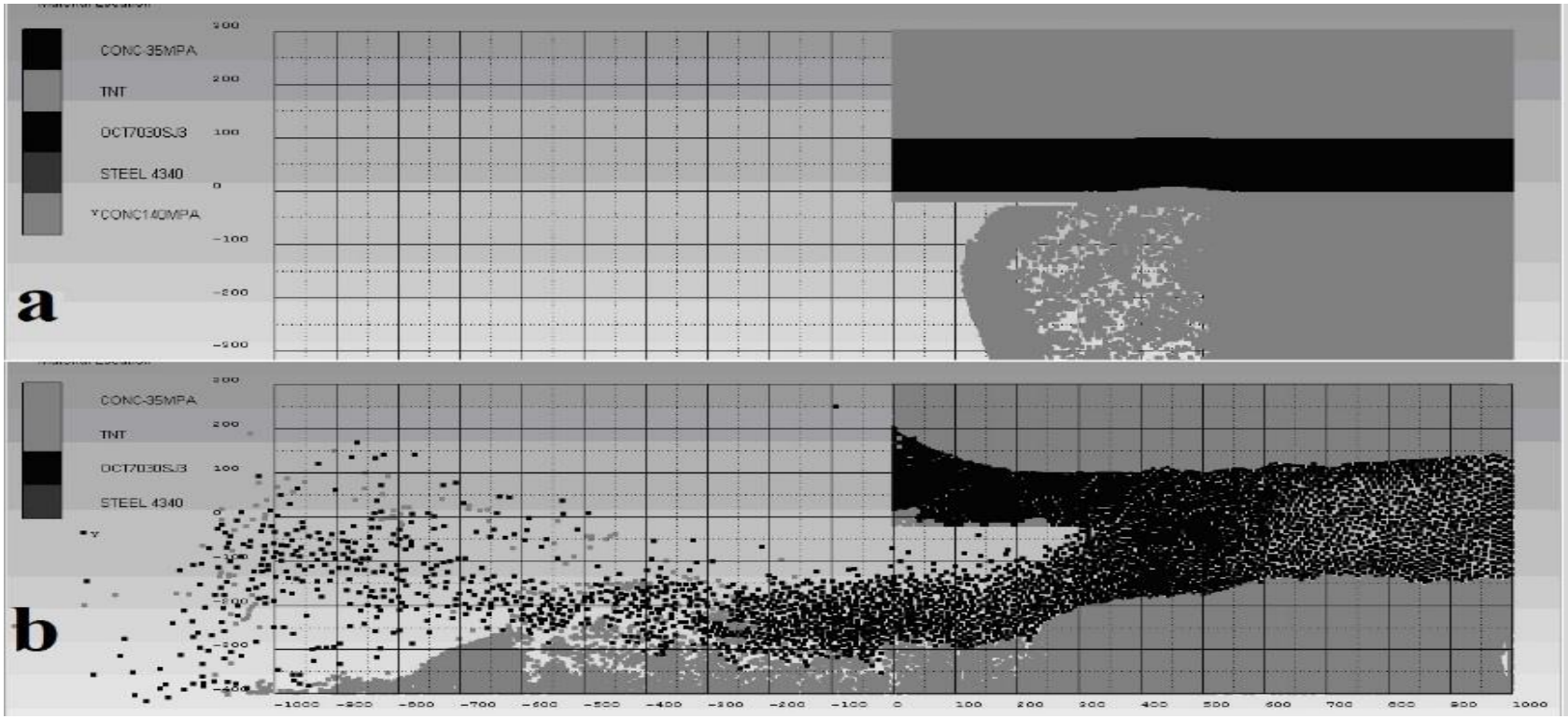
- **Res**-Model describing the microstructural destruction of coal due to man-made stress redistribution in the coal seam, the formation of desorbing microstructural fragments and induced filtration channels in an inhomogeneous environment with an assessment of the possibility of concomitant gas-dynamic phenomena.

- Computer simulation of the stress-strain state of a coal seam with a possible activation of its technogenic impact.

- Res-Numerical model and test calculations of dynamic manifestations using the "energy-saturated" array model.

Numerical simulation

Numerical simulation of changes in the geomechanical state of the host rocks and coal seams during the formation of the worked-out space and identification of the conditions for the dynamic processes of deformation, destruction and gas release.
Patterns of deformation and destruction of the rock mass from the volume of the worked-out space, mining of the converged layers and degassing of the coal seam.



Research of structure of coal

Objectives

Research of changes in the structure of coal, the kinetics of gas recovery, physical and chemical properties, and the tendency to discharge from the stress-strain state during underground mining operations. Determination of the dependence of the heat of methane sorption by coal on its structure and mineral inclusions.

The aim of this work is to develop the theory of multiphase geo - and gas-dynamic processes in a technogenically variable gas- saturated coal-rock massif.
The work is aimed at solving the fundamental scientific problem: - scientific substantiation of the influence of the structural features and material composition of the coal-rock massif on the gas content, physico-chemical properties and thermodynamic conditions of gas- kinetic processes occurring in the coal seam during mining operations.

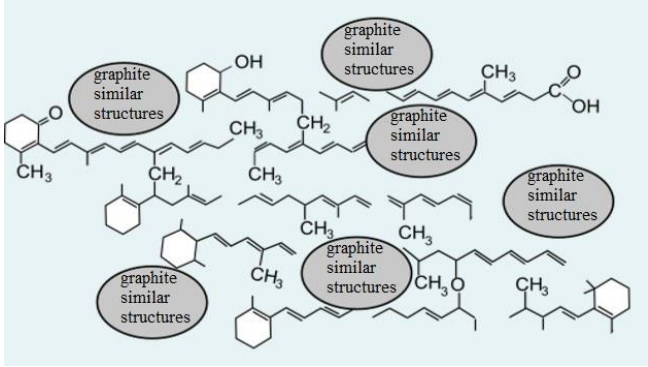
The main objectives of the research are:
- Determination of the influence of the material composition of coal and iron-containing mineral inclusions on its methane content, the thermodynamics of sorption processes and the tendency to spontaneous combustion;
- Study of the features of the structure of fossil coals by the method of multifractal analysis of electronic images and establish a connection with their gas content, physico-chemical, thermodynamic and gas-kinetic properties
- Study of changes in the structure of coal, the kinetics of gas recovery, physical and chemical properties, and the propensity to discharge from the stress-strain state and vibration effects on the coal-rock massif during underground mining operations.

Mechanochemical effect

Methane formation during coal destruction

IR studies have shown that with a sudden release, destruction occurs at the intramolecular level, coal loses a significant part of the aliphatic CH3 groups, the detached radicals (CH3 groups) are chemically active and can, together with no less active atomic hydrogen, also detached from the" fringe " of the coal molecule, form methane

Place of samples collection		Carbon content, % from C^{daf}		Q, m^3/t
		CH_{ap}	CH_3	
Mine Yunkom, seam Mazur	до выброса	11.2	3.1	51.1
	пыль из выброса	14.1	0.1	
Mine Kondrat'evka, seam Aleksandrovskij	до выброса	11.6	2.4	36.7
	из выброса	5.3	0.1	



Schematic model of the structure of coal grades G, W, OS, ⬭ - graphite similar structure

The energy of separation of the methyl group from the coal molecule is 297 ÷ 385 kJ/mol. The binding energy of hydrogen in coal is from 8-40 kJ/mol.

The process of methane formation requires an activation energy of 305 ÷ 425 kJ/mol.

The dissociation energy of methane molecules is 430 kJ/mol (the energy released when a hydrogen atom is attached to a methyl group to form a methane molecule).

Over 90% of gas-dynamic phenomena in mines of Kuzbass, Donbass and Vorkuta is in place mellanlandning plicative and disjunctive tectonic faults, which are difficult to spin bottomhole formation zone, which leads to increased stress.

International cooperation

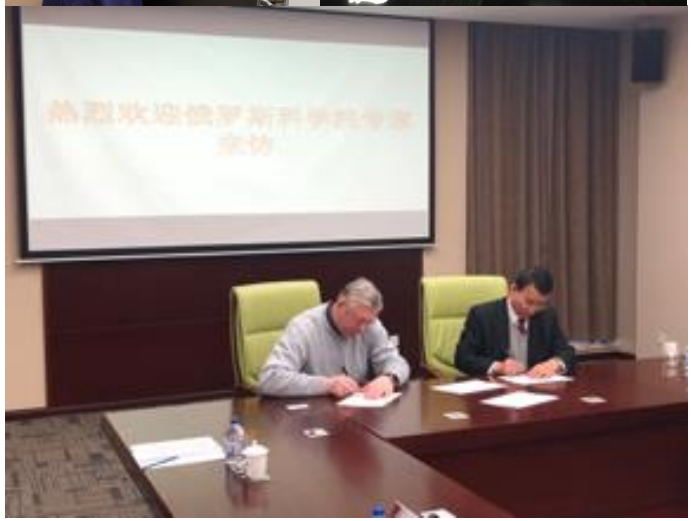
DD-MET project «Advanced methane drainage strategy employing underground directional drilling technology for major risk prevention and greenhouse gases emission mitigation» 2019-2023

Supported by

- Research Fund for Coal and Steel (RFCS)
- Ministry of science and high education of Russian Federation

Attends:

- INSTYTUT NAFTY I GAZU - PANSTWOWY INSTYTUT BADAWCZY (INIG-PIB), Poland
- GLOWNY INSTYTUT GORNICTWA (GIG), Poland
- UNIVERSIDAD DE OVIEDO (UNIOVI), Spain
- POLSKA GRUPA GORNICZA SA (PGG S.A.), Poland
- IMPERIAL COLLEGE OF SCIENCE TECHNOLOGY AND MEDICINE (IMPERIAL), United Kingdom,
- INSTITUTE OF COMPREHENSIVE EXPLOITATION OF MINERAL RESOURCES RUSSIAN ACADEMY OF SCIENCES (ICEMR RAS), Russia



COMPREHENSIVE SCIENTIFIC AND TECHNICAL PROGRAM
«Methane safety and energy efficiency in the development of coal-gas deposits»

КОМПЛЕКСНАЯ НАУЧНО-ТЕХНИЧЕСКАЯ ПРОГРАММА
综合科技项目
«МЕТАНОБЕЗОПАСНОСТЬ И ЭНЕРГОЭФФЕКТИВНОСТЬ ПРИ РАЗРАБОТКЕ УГЛЕГАЗОВЫХ МЕСТОРОЖДЕНИЙ»
安全高效开采煤层气

СОГЛАСОВАНО:同意
Директор ИПКОН РАН
Захаров В.Н.
«___» _____ 2019 г.

СОГЛАСОВАНО:同意
Генеральный секретарь МЦУМ Шаньси КНР
Jia Qing Rong
«___» _____ 2019 г.

Thank you for your attention!