INTELIGENT MINE CLOSURE, A CASE STUDY BASED ON THE AMMUSCB PROJECT, A FIRST AMM CAPTURE AND UTILISATION PROJECT IN POLAND

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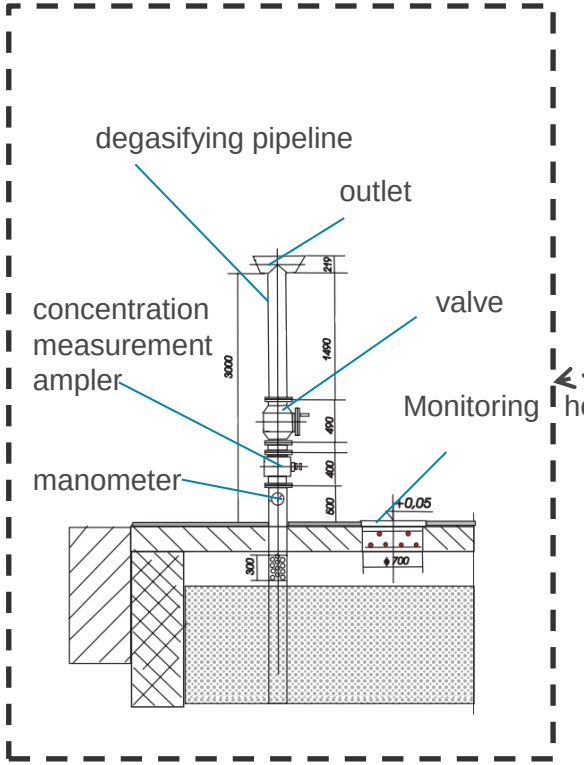
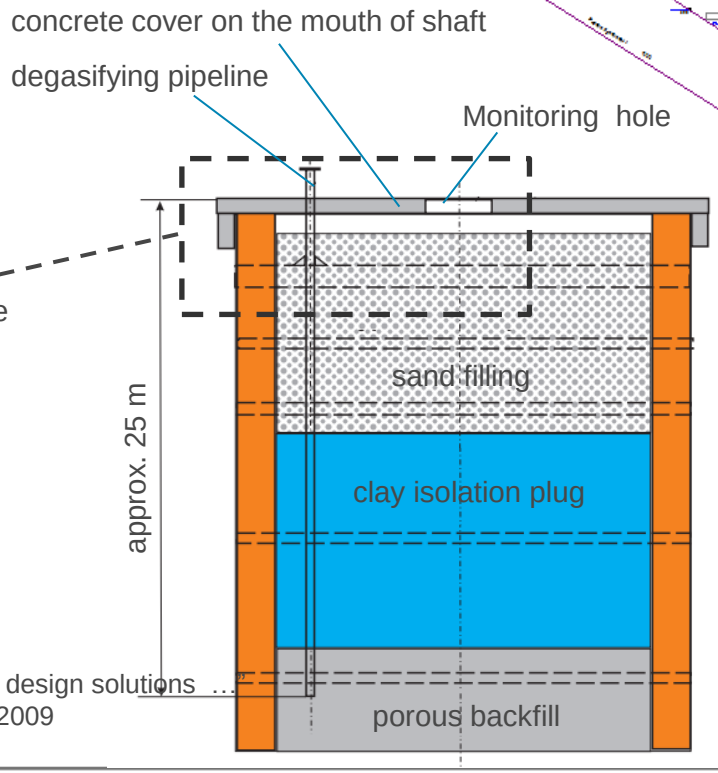
ICE-CMM, Post-Mining Perspectives: Capture and Use of AMM and Reclamation and Revitalization of Post Mining Areas

LIQUIDATION OF SHAFTS

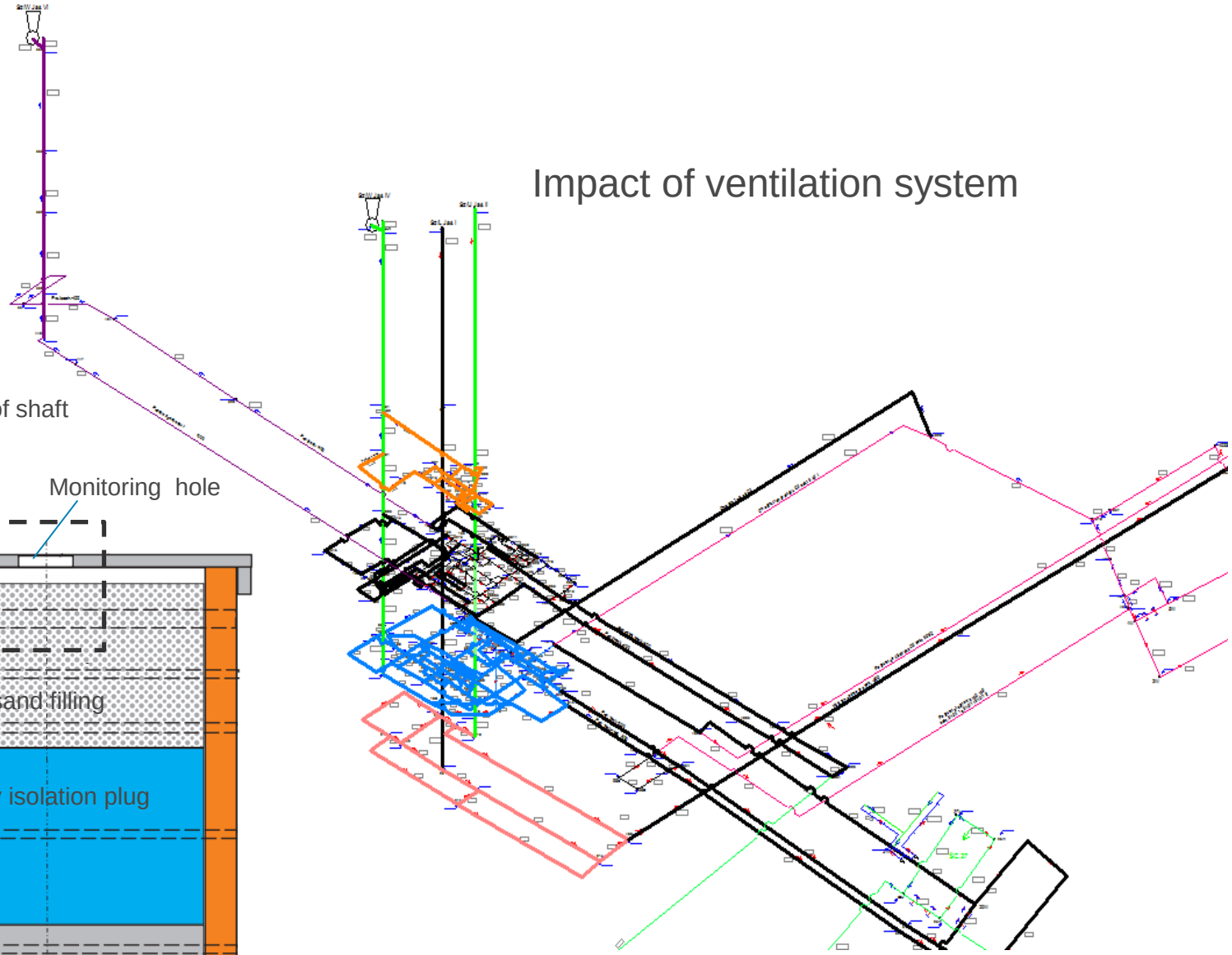
Technology of decommissioning the shafts





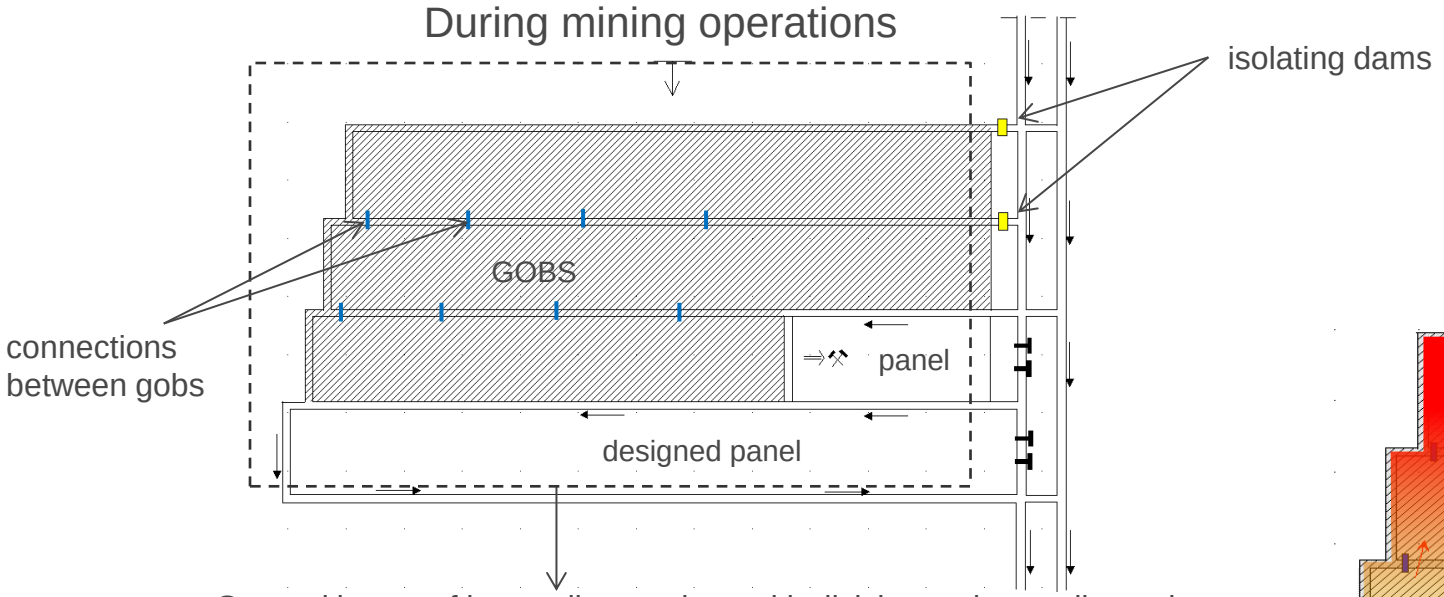
by Czaja P. „Estimation of shafts' decommissioning design solutions …"
Mining & Geoengineering , year 33, notebook 3/1, 2009

Impact of ventilation system

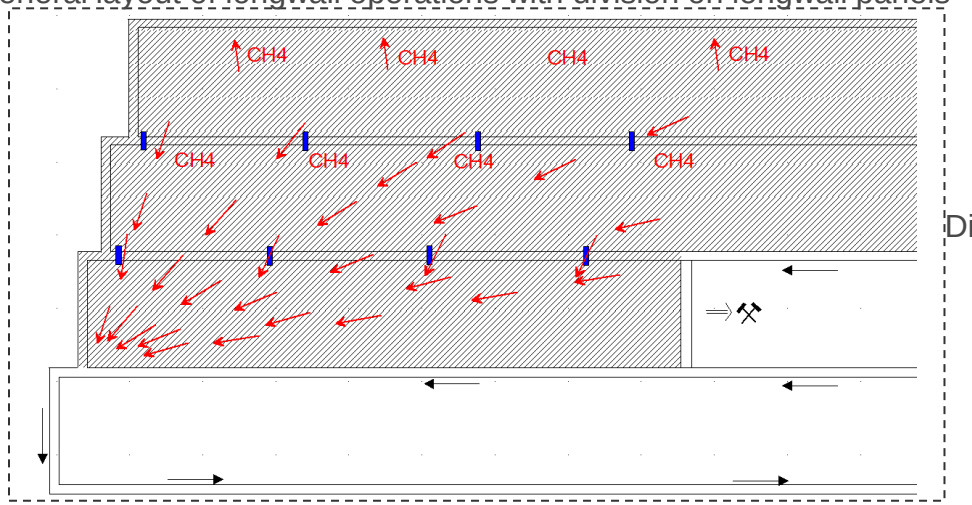


LIQUIDATION OF THE COAL PANELS WITHIN ONE SEAM

During mining operations

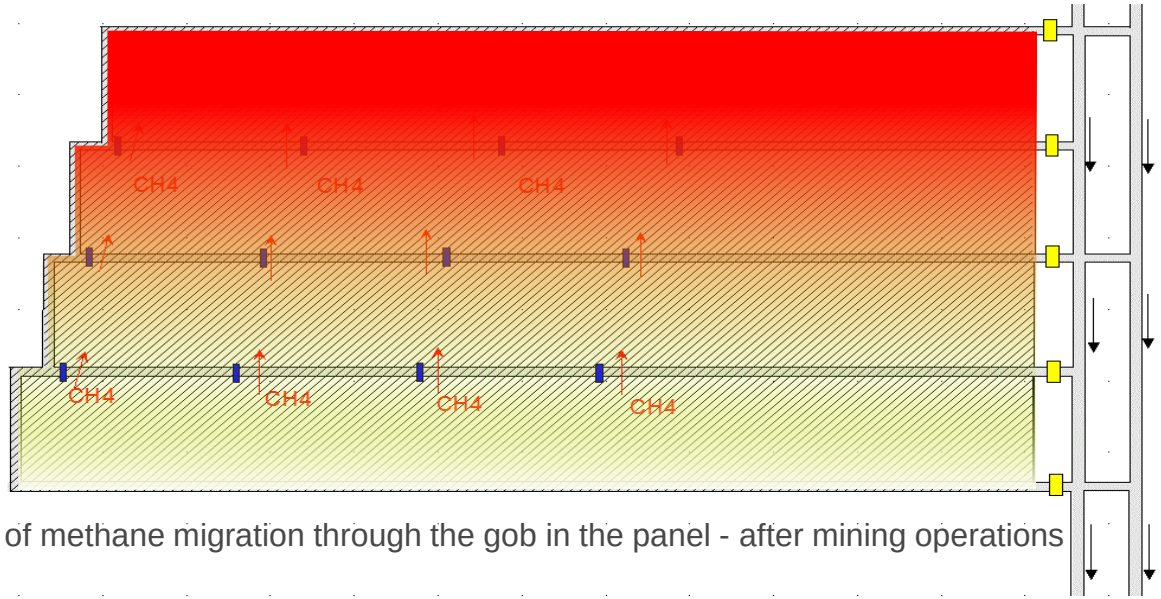


General layout of longwall operations with division on longwall panels



Direction of methane migration through the gob in the panel - during mining operations

After completing mining operations
Methane reservoir in connected gobs



Direction of methane migration through the gob in the panel - after mining operations

direction of methane migration through the gob

direction of air flow in the workings

LIQUIDATION OF THE COAL PANELS WITHIN ONE SEAM

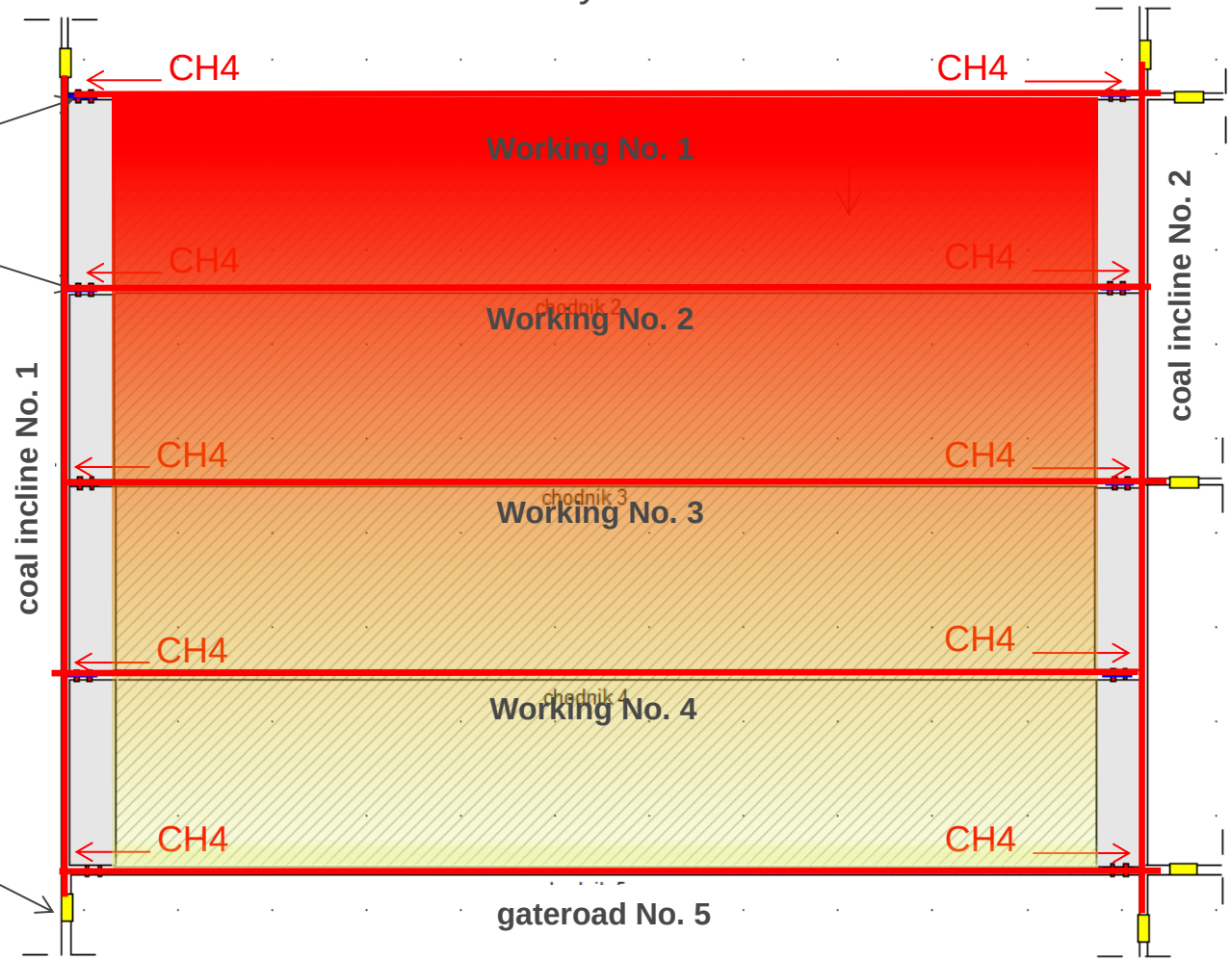
Usage of workings in the same coal seam after completing mining operations

Methane reservoir in the gobs connected by coal inclines

Depressurisioning of the isolating dams (opened feedthroughts in dams)

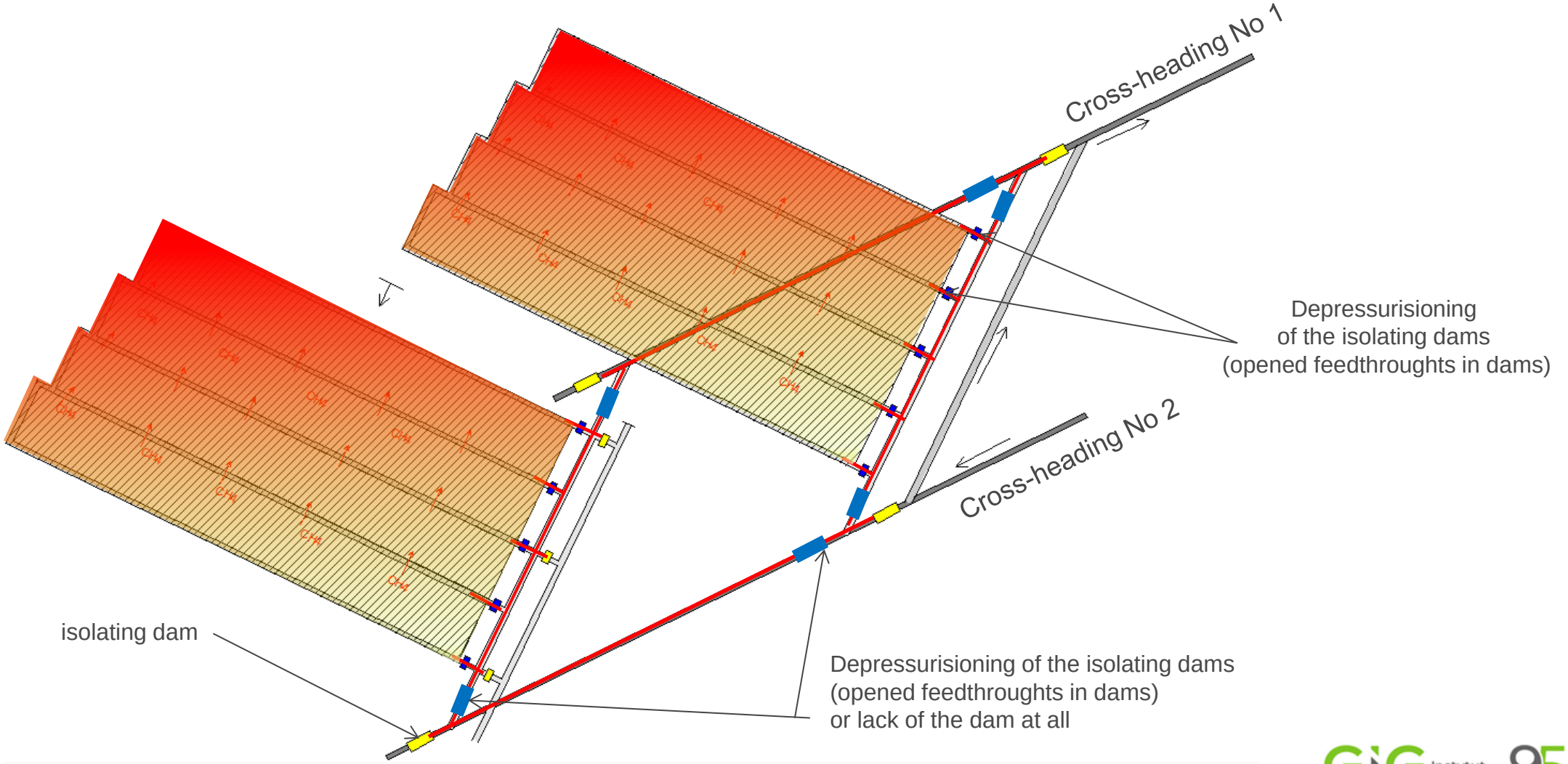
direction of methane flow through the dams

isolating dam



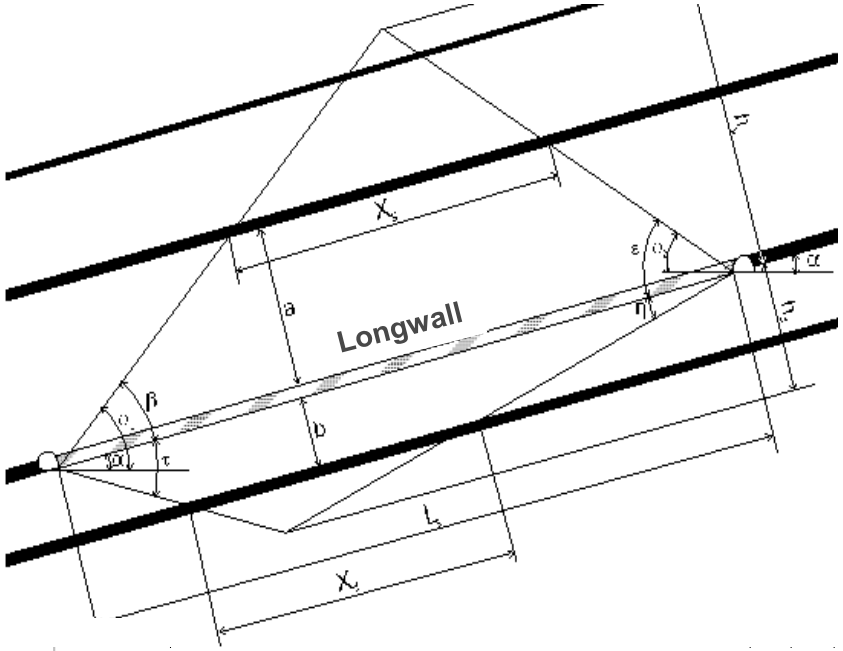
LIQUIDATION OF ALREADY EXPLOITED COAL PANELS IN MANY SEAMS

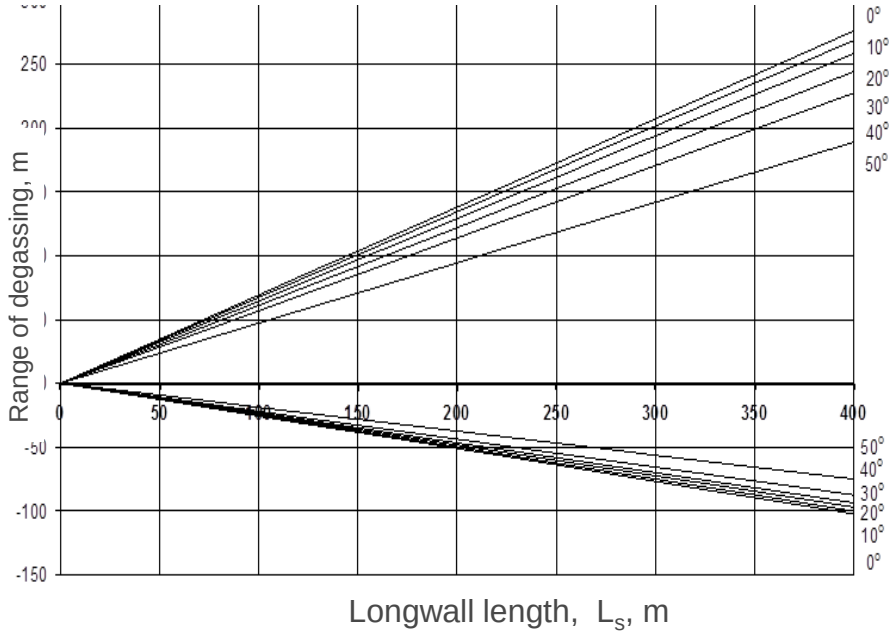
After completing mining operations - usage of workings outside the seam, e.g. cross-headings

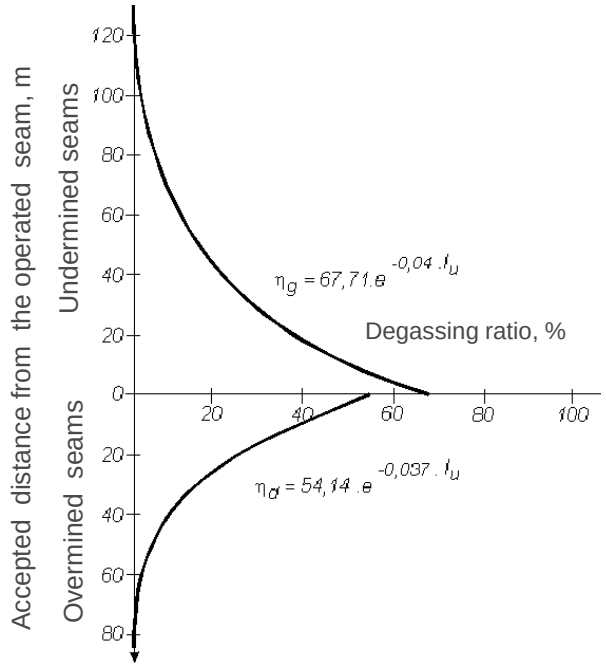


EVALUATION OF AMM RESOURCES

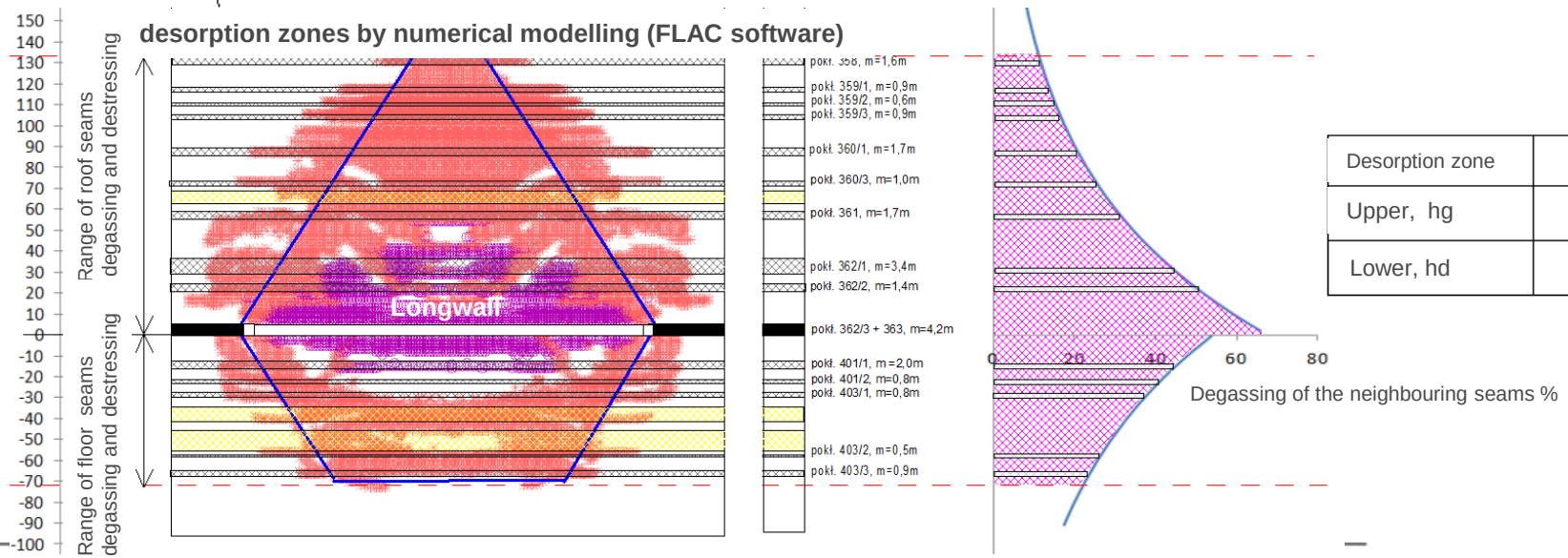
Desorption zones used by Central Mining Institute (CMI)







desorption zones by numerical modelling (FLAC software)



For incline 0 °

Desorption zone	**Ls =150m**	Ls=200m	**Ls=250m**	Ls=300m
Upper, hg	103	138	172	207
Lower, hd	38	51	64	77

$h_g = L_s/1.45 = 0.69\ L_s$

$h_d = L_s/3.91 = 0.26\ L_s$

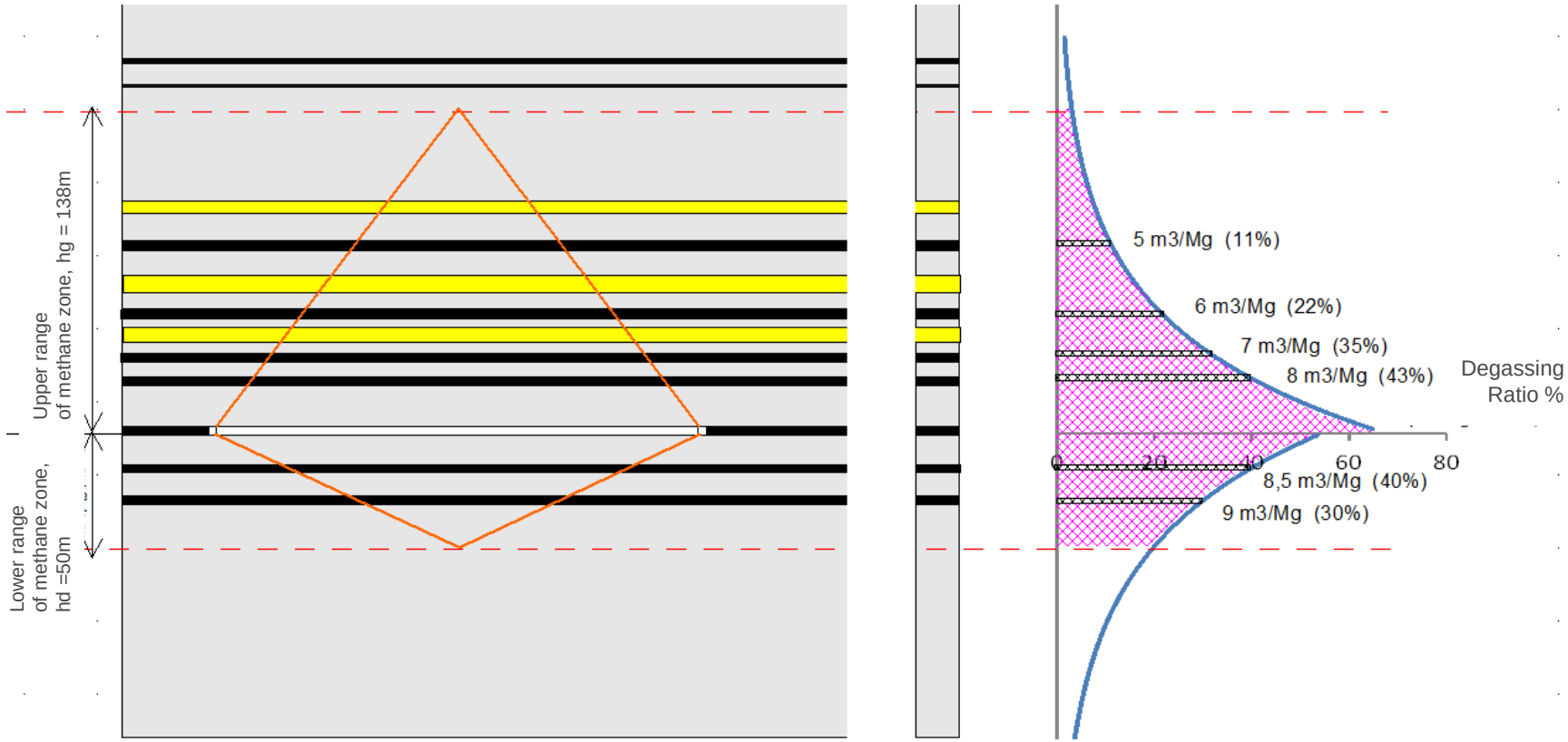
EVALUATING OF AMM RESOURCES

Example case

Longwall parameters:
Length, Ls = 200m
thickness, h = 1.8m
panel lenght: 1,465m
daily output: 2,100 Tons/ d
daily advance, p = 4.5 m/d
methane content in mined seam,
W = 7.4 m^3CH_4/MgD_{daf}

Overlaying coal seams, in the roof:
number of seams: 4
average thickness of seam: 2m,
distance from exploited seam: 20-80m
methane content, W = 5-8 m^3CH_4/Mg_{daf}

Underlaying coal seams, in the floor:
number of seams: 2
average thickness of seam: 2m,
distance from exploited seam: 15-30m
methane content, W = 8,5-9 m^3CH_4/Mg_{daf}

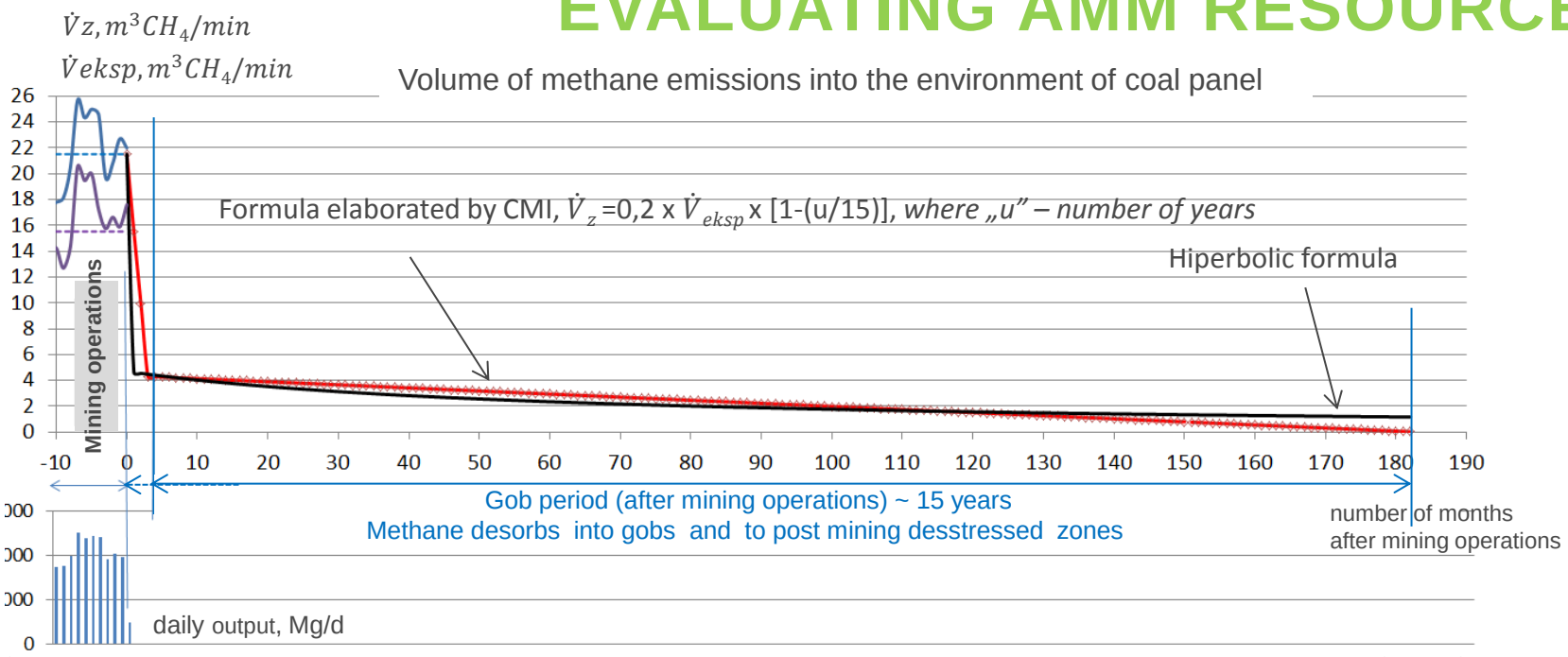


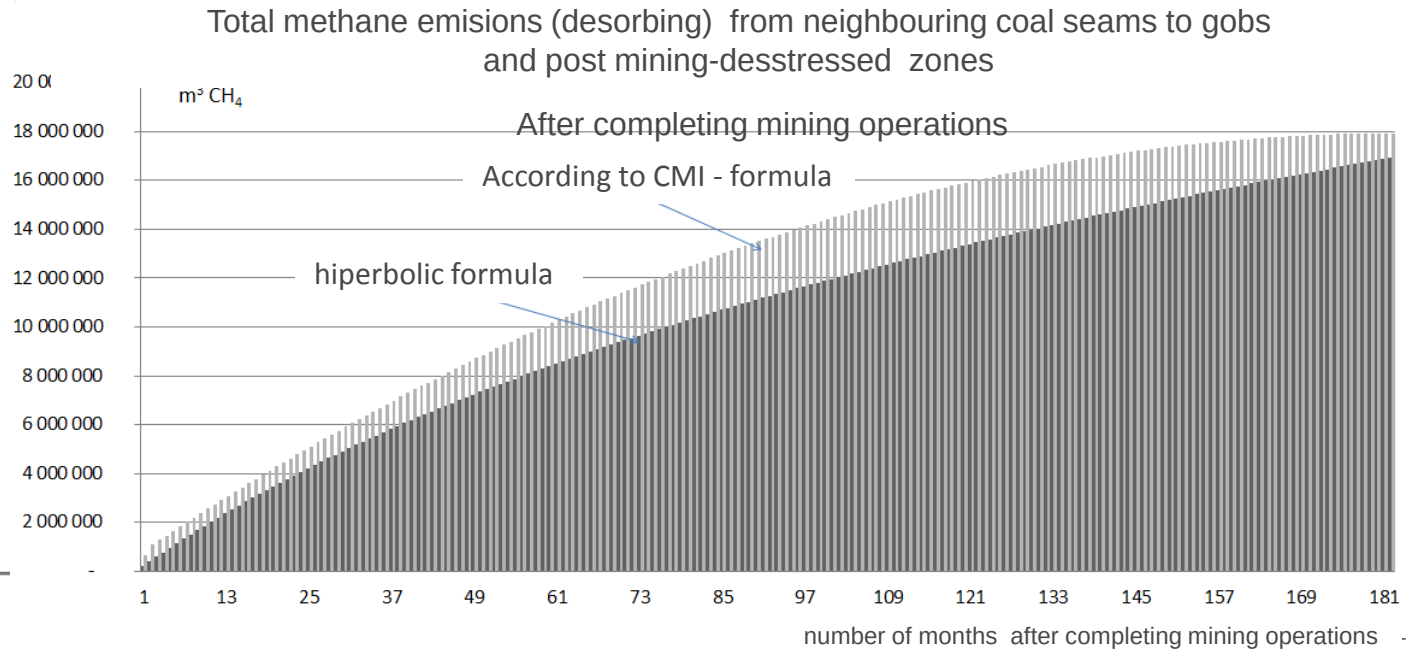
Methane resources released after completing mining operations:
- V_{AMM} = **17,921,507 m³**
(methane desorbing from neighbourhood seams)

Methane resources released during mining operations V_{EKSP} = **12,526,470 m³**
including:
- from exploited coal seam: 2,746,644 m³
- from neighbouring seams: 9,779,826 m³

$$V_{AMM} = 1,4\ V_{EKSP}$$

EVALUATING AMM RESOURCES





Methane resources released during mining operations:

- V_{EKSP} = **12,526,470 m³**

including:

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- from neighbouring seams: 9,779,826 m³

Methane resources released after completing mining operations:

- V_{AMM} = **17, 921, 507 m³**

(methane desorbing from neighbouring seams)

$$V_{AMM} = \int_0^{t=180} \dot{V}z\, dt$$

$$V_{AMM} = 1{,}4\ V_{EKSP}$$

Assuming for gassy coal mine:

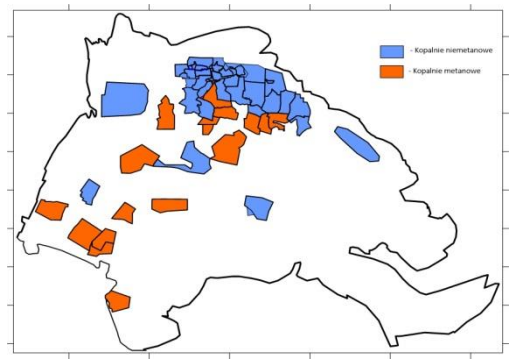
- 3 coal panels operated per year,
- operation period – 10 years

one can get Potential Methane Capture in amount:

$$V_{AMM} = 537 \text{ mln m}^3\ CH_4$$

GIG Instytut Badawczy 95 lat

CAPTURE AND UTILISATION OF METHANE FROM ABANDONED COAL MINES IN THE UPPER SILESIAN COAL BASIN



Acronym: AMMUSCB

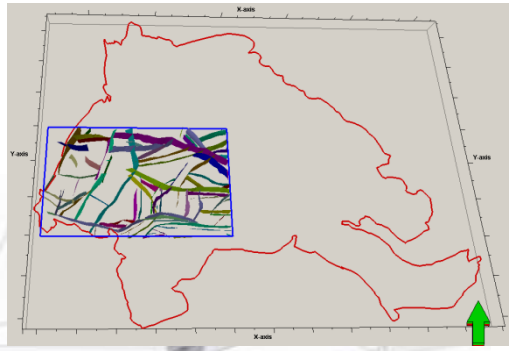
The project is carried out by consortium: Central Mining Institute (as a leader) and AGH Technical University of Science and Technology

Financed by:

PGNiG - (in English) Polish Oil and Gas Company

NCBiR - (in English) National Center for Research and Development

Realisation period: 2019 -2022



PROGRAM INGA

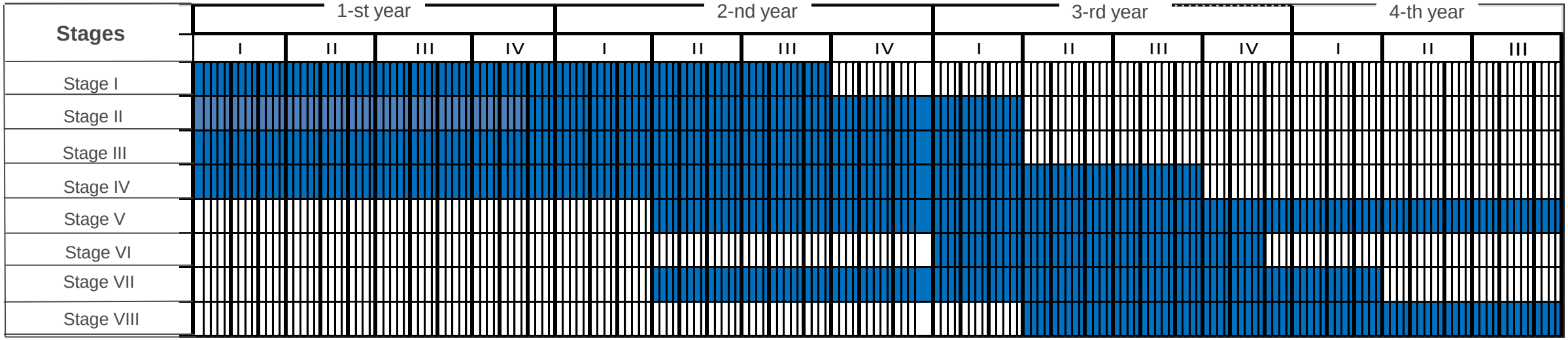
AMMUSCB project objectives:

Main: ecological - environmental protection by reducing methane emissions to the atmosphere from the closed and liquidated mines.

Additional: economical – the possibility of using methane for energy or heating purposes.

Methods to achieve the objectives - designing and verifying the technology of methane capture and its use by drilling a well from the surface to several goaf spaces located in the coal seams at different depths. Above method assumes drilling through several goafs, thanks to this it should provide access to larger space of goafs and methane resource potential automatically.

This solution should ensure a multiplication of methane extraction and increase the efficiency of methane drainage compared to conventional methods of methane drainage from the gobs located in single seam. In fact, this method should also have impact on reduction of uncontrolled methane emissions into the atmosphere.

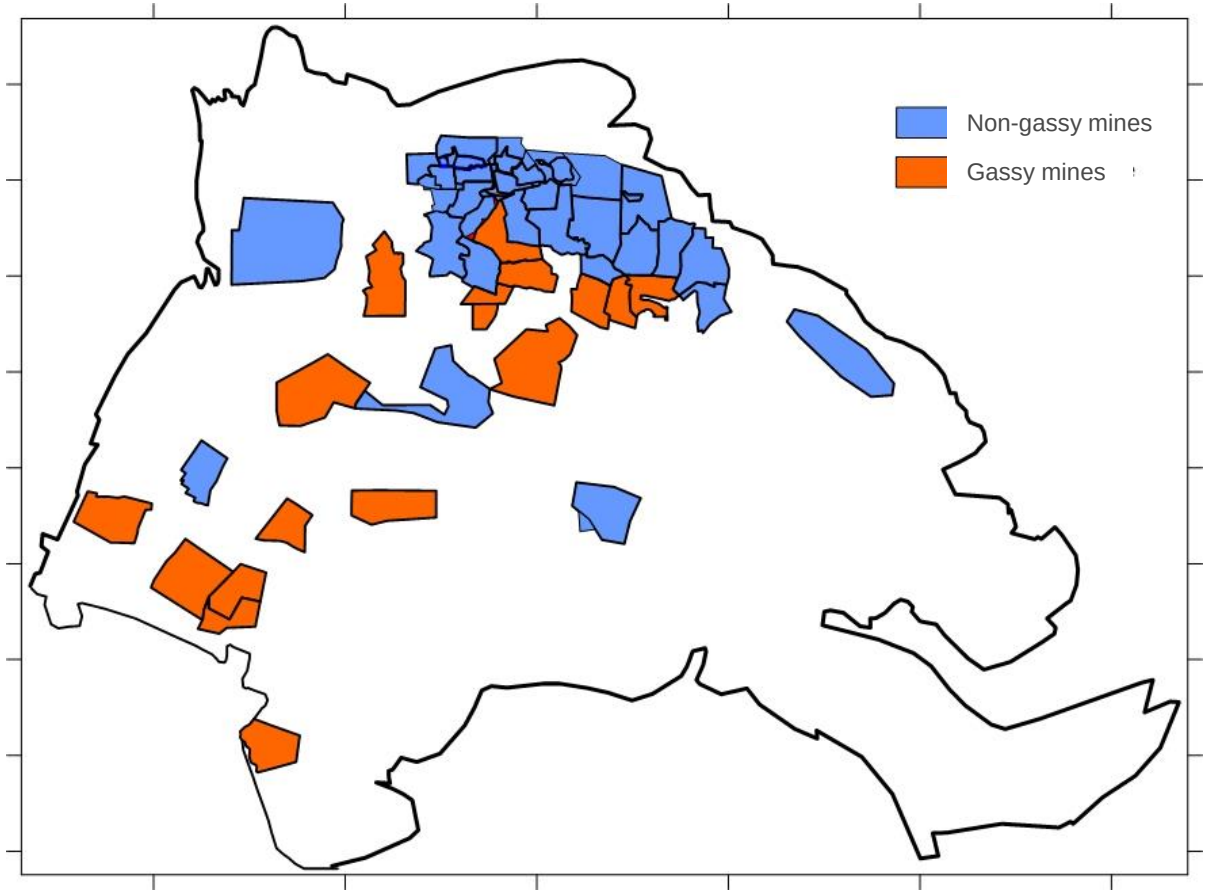


Stage I	Retrospection of archival data in terms of methane recovery from closed mines
Stage II	Identification of potential methane capture areas associated with the completed extraction of coal seams
Stage III	Location of pilot well based on the results of numerical modelling and geological and mining conditions
Stage IV	Environmental assessment of methane capture from several post-mining goafs from active and closed coal mines
Stage V	Preparation of an innovative method of methane capture from several post-mining goafs
Stage VI	Works on the pilot capture of methane from several post-mining goafs from closed coal mines
Stage VII	Preparation of comprehensive methodology for assessing the economic aspects of methane capture
Stage VIII	Analysis of methane utilisation possibilities

Stage II - Identification of potential methane capture areas associated with completed extraction of coal seams

Research area of the project:

- **Mines abandoned and currently being liquidated,**
- active mine/ mines in operation with areas being liquidated or planned to be liquidated within next 5 years.



Map of currently being liquidated and abandoned mines in USCB

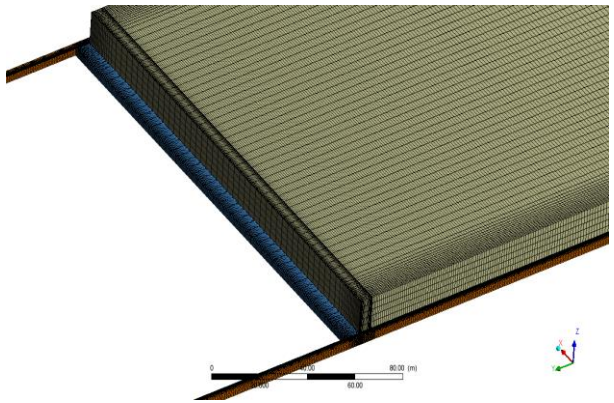
Criteria of identification:

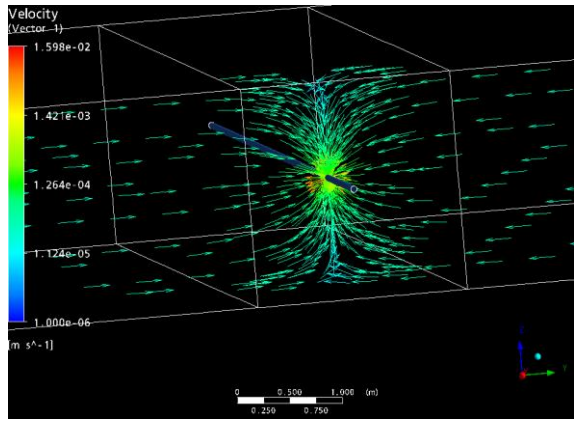
- period of time from completion mining operations,
- the volume of already excavated deposits,
- methane content of presently exploited coal seams,
- connections between mines,
- overburden tightness,
- water inflow to mines,
- dewatering,
- Methane emissions (absolute methane bearing capacity)

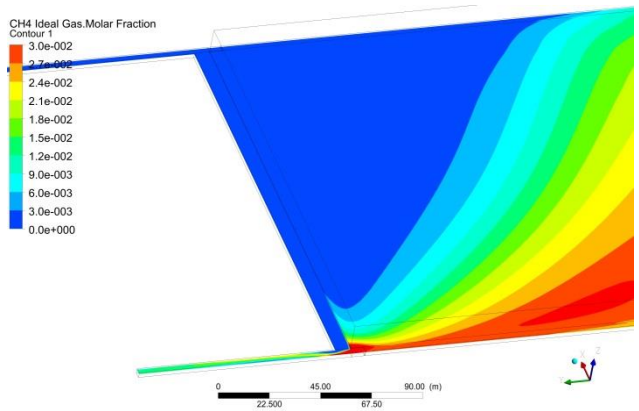
Stage II - Identification of potential methane capture areas associated with completed extraction of coal seams

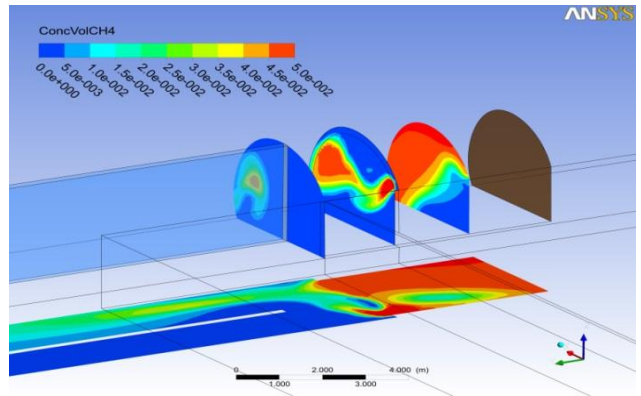
Research area of the project:
- mines decommissioned and being presently liquidated,
- **active mine/ mines in operation with areas being liquidated or planned to be liquidated.**

1. Selection of closed areas in the mines for their effective methane drainage (JSW, PGG)
2. Preparation of ventilation network characteristics for selected areas of the mines,
3. Construction of spatial geometric models of flow areas,
4. Variant numerical calculations of methane capture from the goafs (CFD method),
5. Variant numerical calculations of methane concentration distribution in goafs, depending on the order of sealing the regions (by dams) and making interconnections between the goafs (CFD method),
6. Analysis and evaluation of individual liquidation scenarios (simplified ventilation grid) for methane migration in gobs and methane emission from gobs.



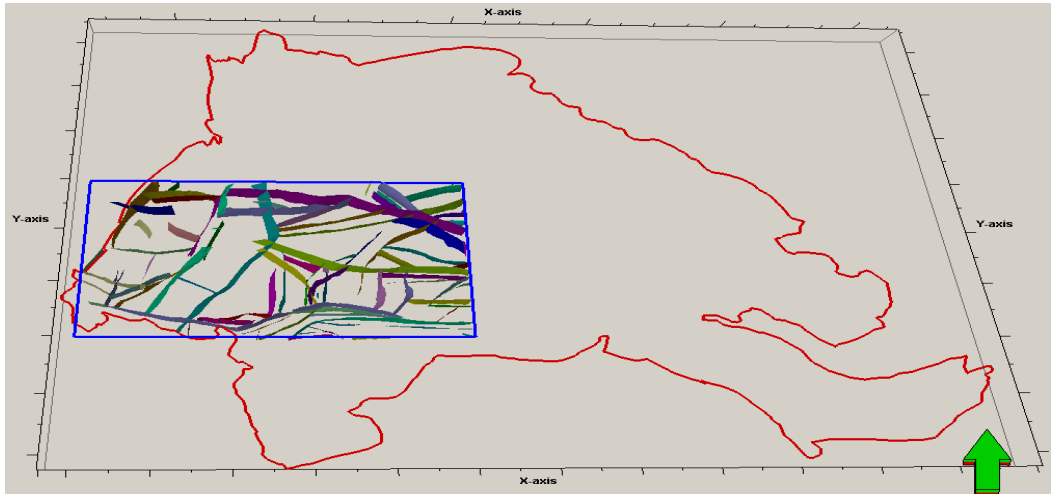




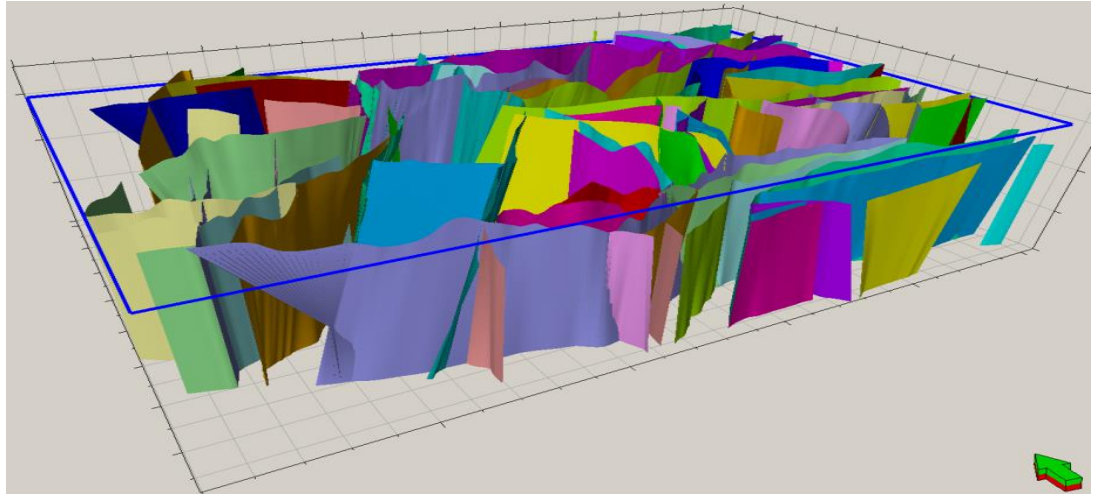


Stage III - Location of pilot well based on the results of numerical modelling and geological and mining conditions

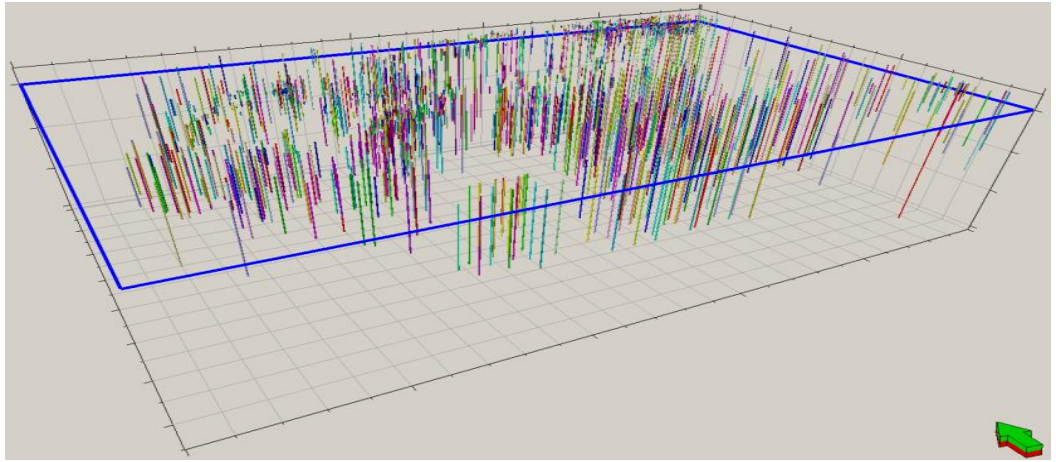
Model of faults in selected region of USCB



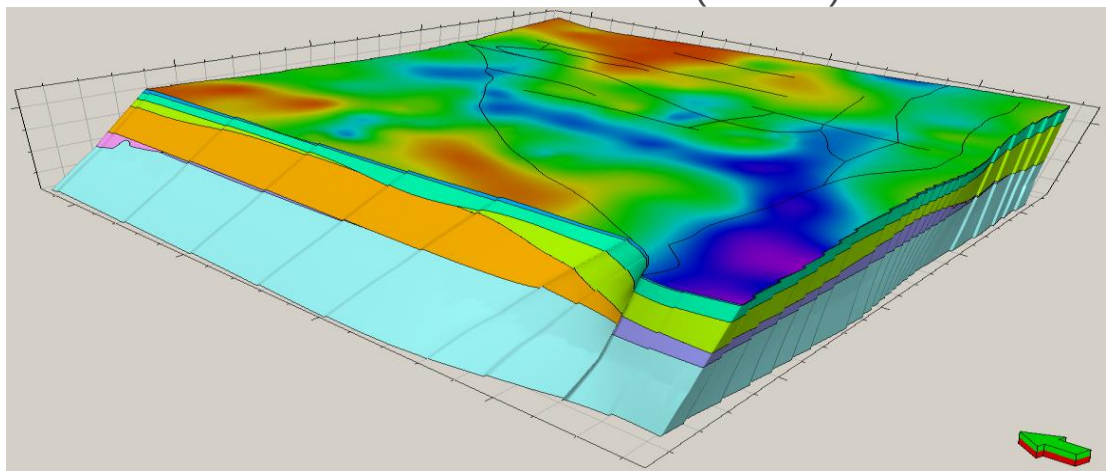
Contour of the detailed model on the background of the regional model of tectonic discontinuities



The location/distribution of the wells in the modelled area

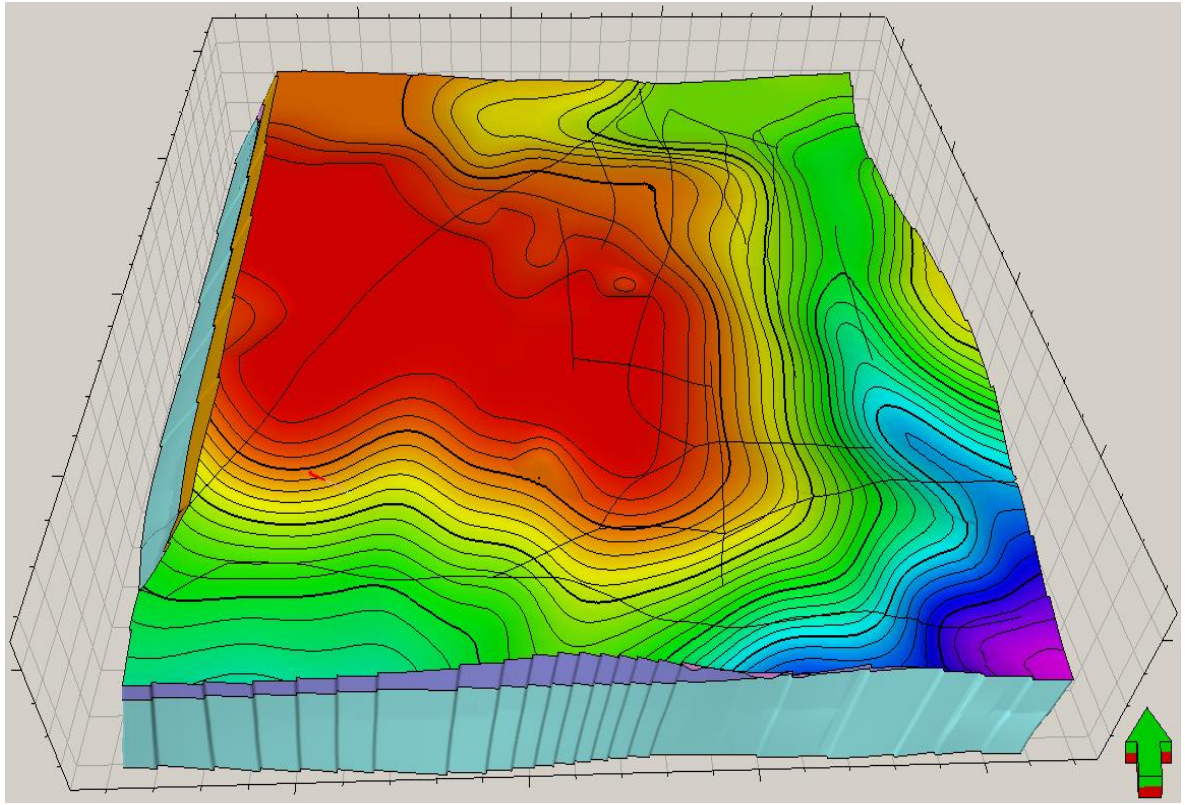


3D model view S-W (surface)

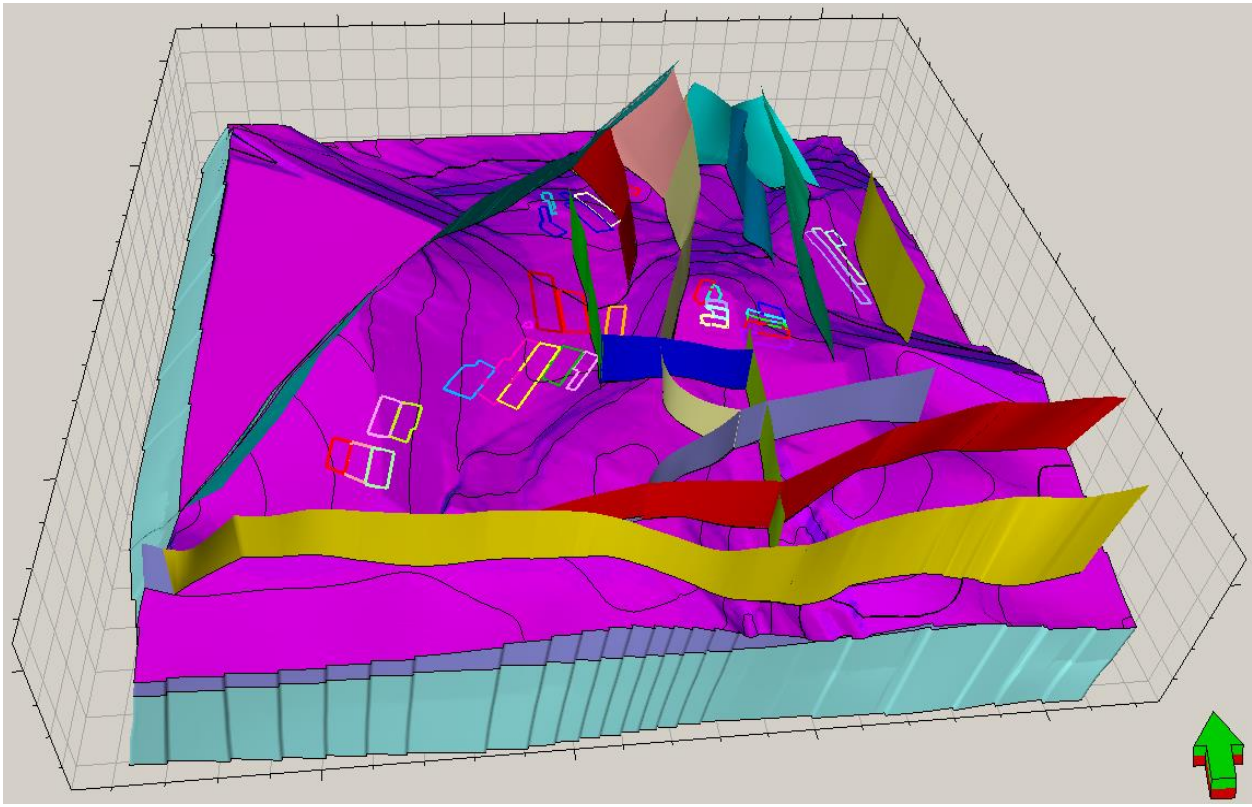


Stage III - Location of pilot well based on the results of numerical modelling and geological and mining conditions

3D model - surface of carbon roof area
(PETREL software)

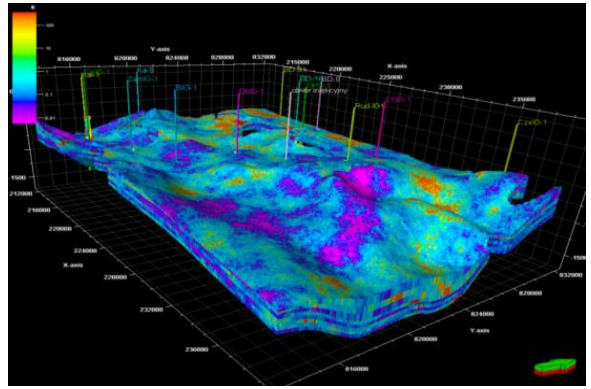


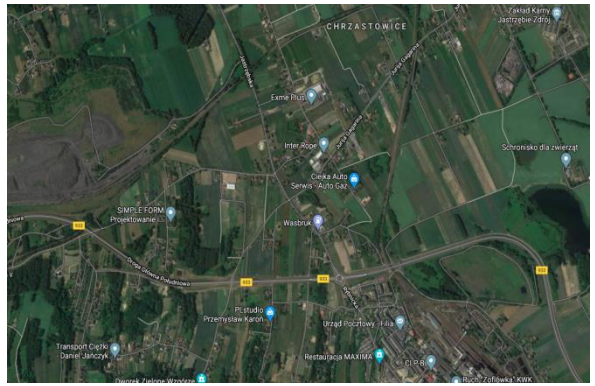
3D model – coal seam, faults, location of gobs
(PETREL software)

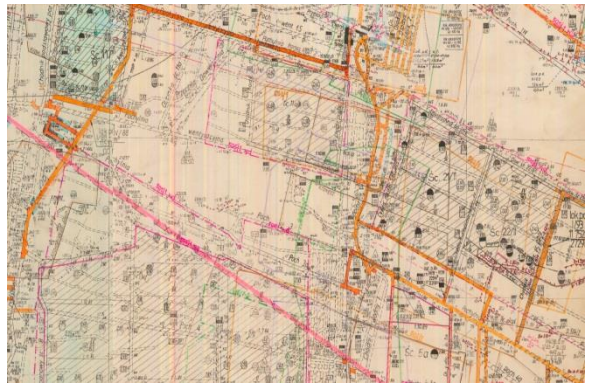


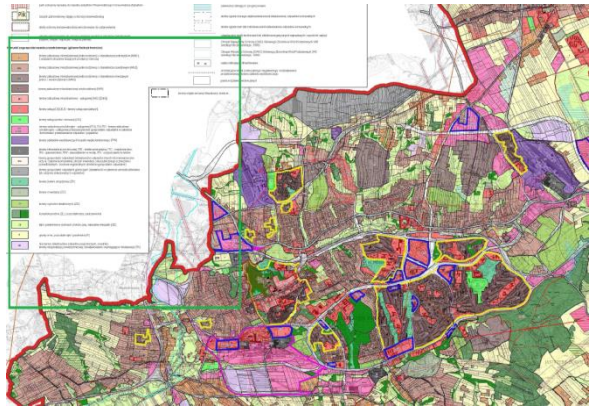
Location of reseache pilot well

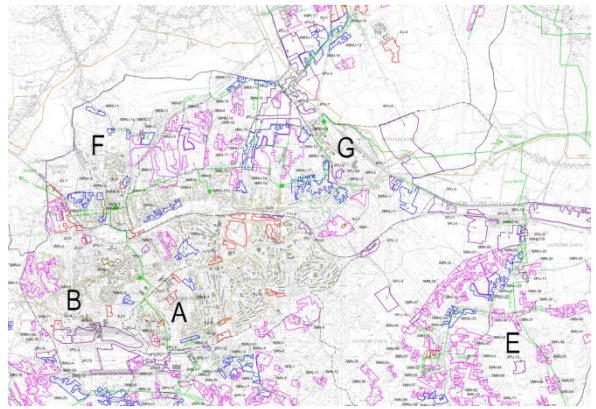
- Model calibration based on historical data,
- Selection of potential areas for the location of wells,
- Analysis of numerical methane capture simulations based on a dynamic deposit model,
- Analysis of restrictions related to surface and underground infrastructure,
- Analysis of current environmental conditions,
- Analysis of gas network location and potential gas consumers,
- Variable simulations for boreholes,
- Selection of the most efficient well.





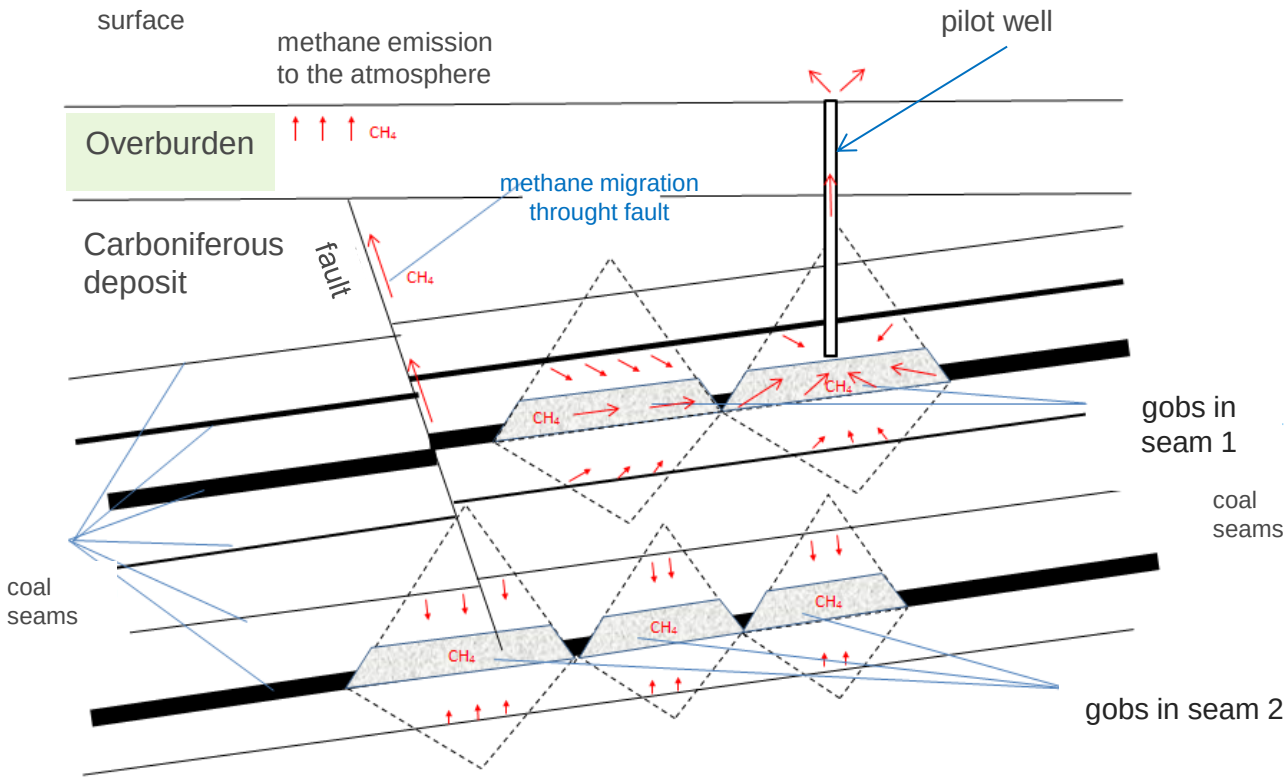




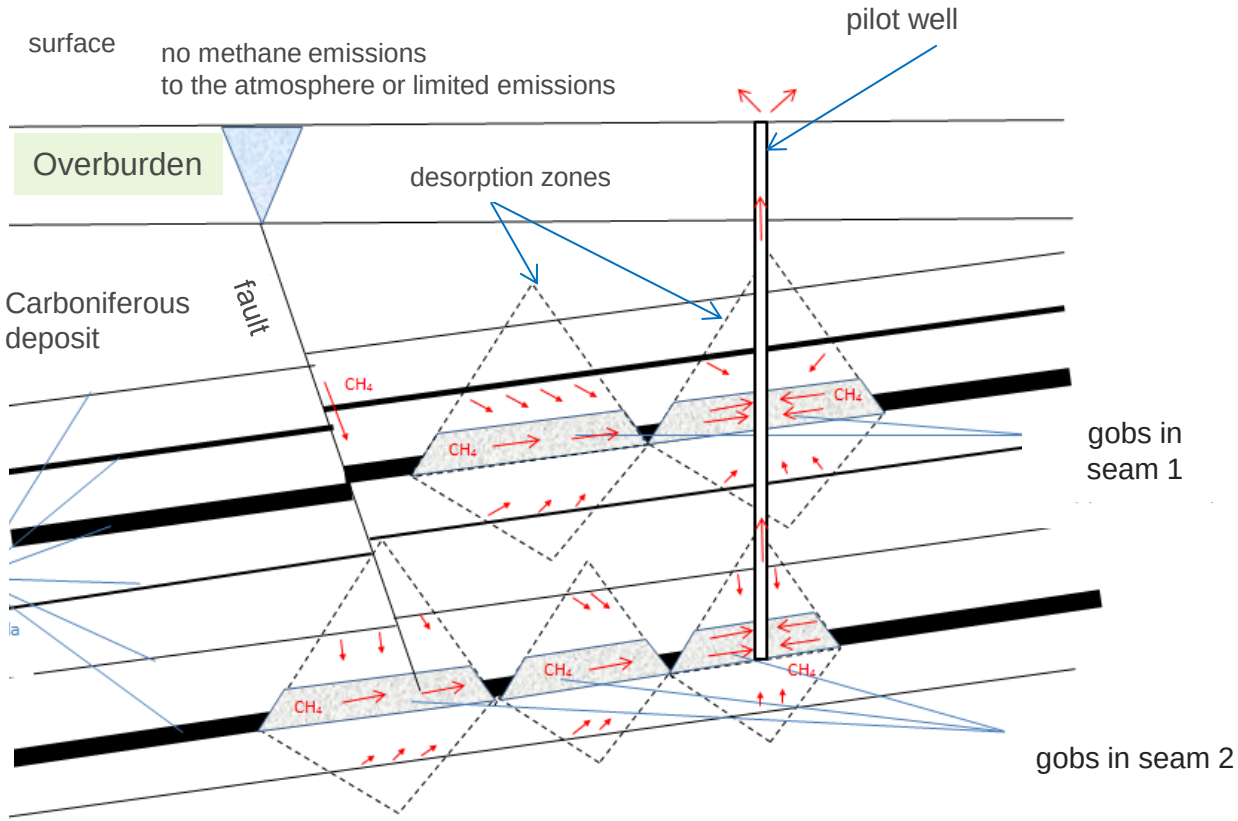


Stage VI - Works on the pilot capture of methane from several post-mining goafs from closed coal mines

Assumptions regarding drilling



Example of well drilled down to the gobs located in one coal seam .



Example of the well drilled down to the gobs located at different depths (in different coal seams).
Capture of methane - directly from two gobs.

Stage VI - Works on the pilot capture of methane from several post-mining goafs from closed coal mines

A) Project of the well,

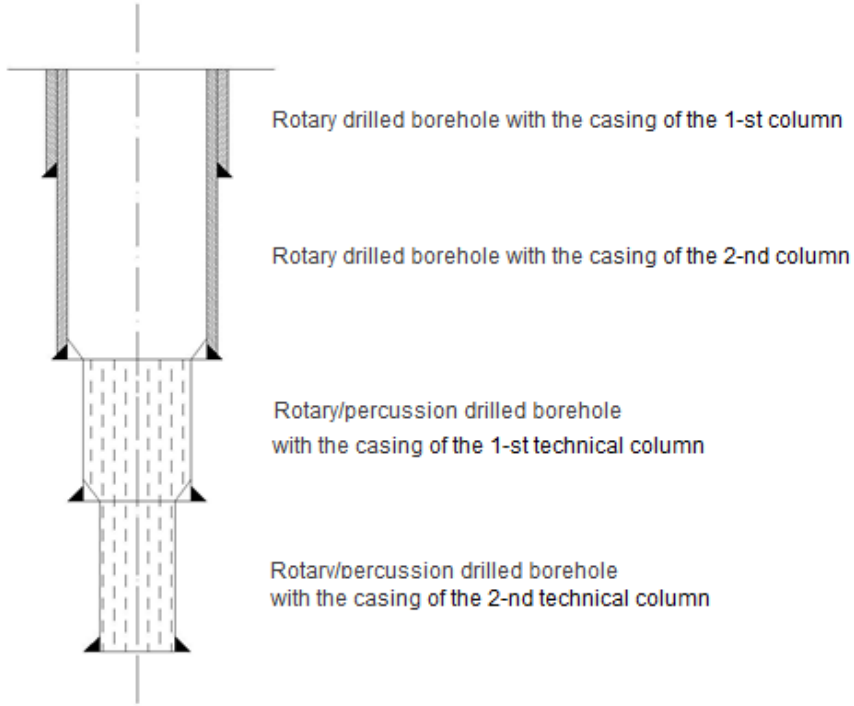
B) Obtaining permissions,

C) Drilling the well and:

- performing rocks' fragment profile to make sure what is real profile of encountered strata
- verification of mechanical and hydraulic drilling parameters determined in the project,
- sampling for laboratory tests,
- preparation of drilling report.

D) Measurements:

- deposit pressure,
- quantinities of goaf gases,
- methane content in goaf air,
- chemical composition of the goaf air.



Borehole example with two technical columns

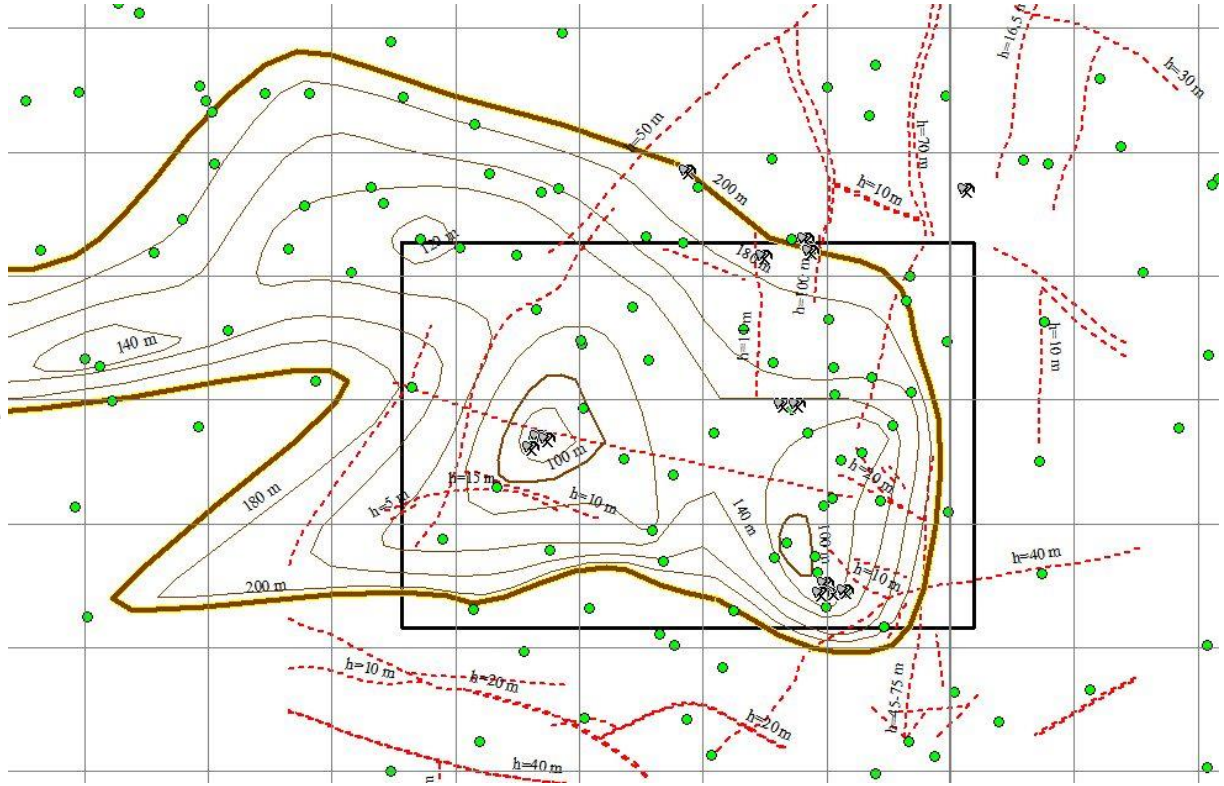
Stage IV- Environmental assessment of methane capture from several post-mining goafs from active and closed coal mines

A) **Atmogeochemical tests**
Location: shafts, wells, faults and other tectonic discontinuities.
Method: borehole method (1.5m deep well perforated at the length of 0.5m from its bottom), measurement chamber method.
Frequency: after 48h, after 7 days and 14 days.

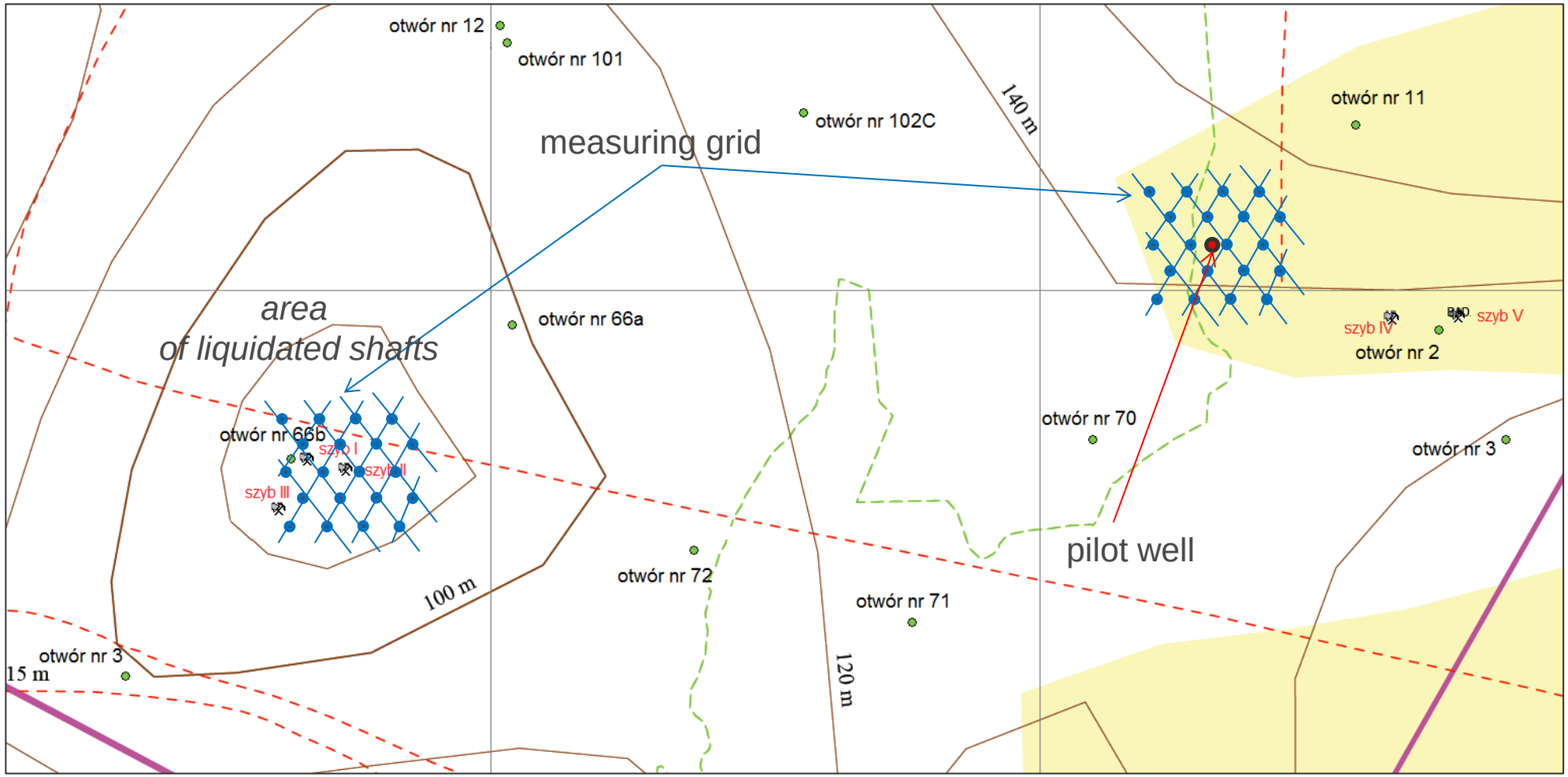
When higher methane concentrations are detected, additional carbon isotope determination tests will be carried out to identify the origin of the methane: thermogenic (from the coal mine) or biogenic.

B) **Preparation of an environmental risk analysis methodology for the optimal location of wells**
- identification of environmental impact,
- determination of environmental criteria.

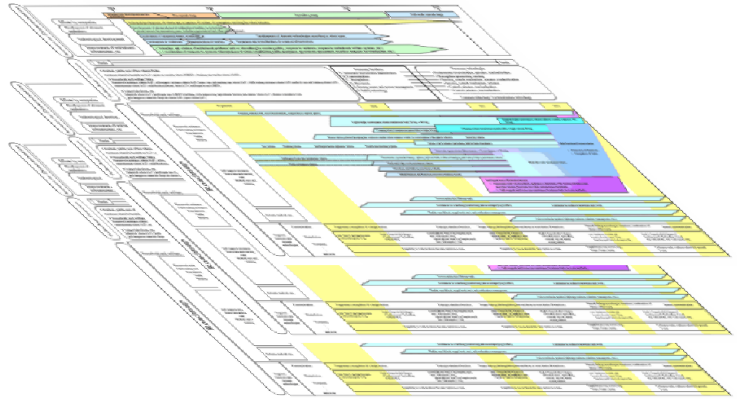
C) **Assessment of environmental impact of methane extraction technology**
- monitoring of noise during pilot well drilling operations and well tests performance,
- modelling the spread of pollution (emission from drilling rig drive and other equipment).



Stage IV- Environmental assessment of methane capture from several post-mining goafs from active and closed coal mines



Stage VIII - Analysis of methane utilisation options



1. Maps of methane efficiency technology under specific local conditions
2. Selection of the best technologies for energy utilisation of methane for a specific location of wells.
3. Determination of parameters required to implement selected conversion techniques of methane to energy e.g. for gas turbines, internal combustion engines, cooperation with existing energy sources, interaction with local heating networks, compression, liquefaction into LNG, introduction of gas into natural gas pipelines.
4. Functional models will be developed for the pilot well and following wells.
 These models will combine the following:
- reservoir parameters,
- transmission parameters,
- conditioning parameters,
- parameters of chemical use of gas,
- parameters of energy use of gas

with the characteristics of customers and the needs of own installation

5. Determination of environmental impact, with indication of legal limitations.
6. Validation of the numerical deposit model.

CONCLUSIONS

The project is focused on closed mines and parts of active gassy mines planned for liquidation, belonging to **JSW S.A**.(**J**astrzębska **S**półka **W**ęglowa) and **PGG S.A.**(**P**olska **G**rupa **G**órnicza) coal concerns.

Positive results of the project will allow for implementation of the method on industrial scale, which will result in multiplication of total amount of methane captured from the mine and increase the efficiency of methane drainage with single well – comparing with conventional drainage of gobs located in one coal seam.

Additional effect of the project will be reduction of methane drainage costs due to the possibility of decreasing number of drainage boreholes.

The technology to be developed as a result of this project should be particularly beneficial in Upper Silesian Coal Basin (USCB), due to its multi-level coal seams exploitation and relatively recent closure of gassy coal mines.