APPLICATION OF LONG-REACH DIRECTIONAL DRILLING

for gas drainage of adjacent seams in coal mines with severe geological conditions

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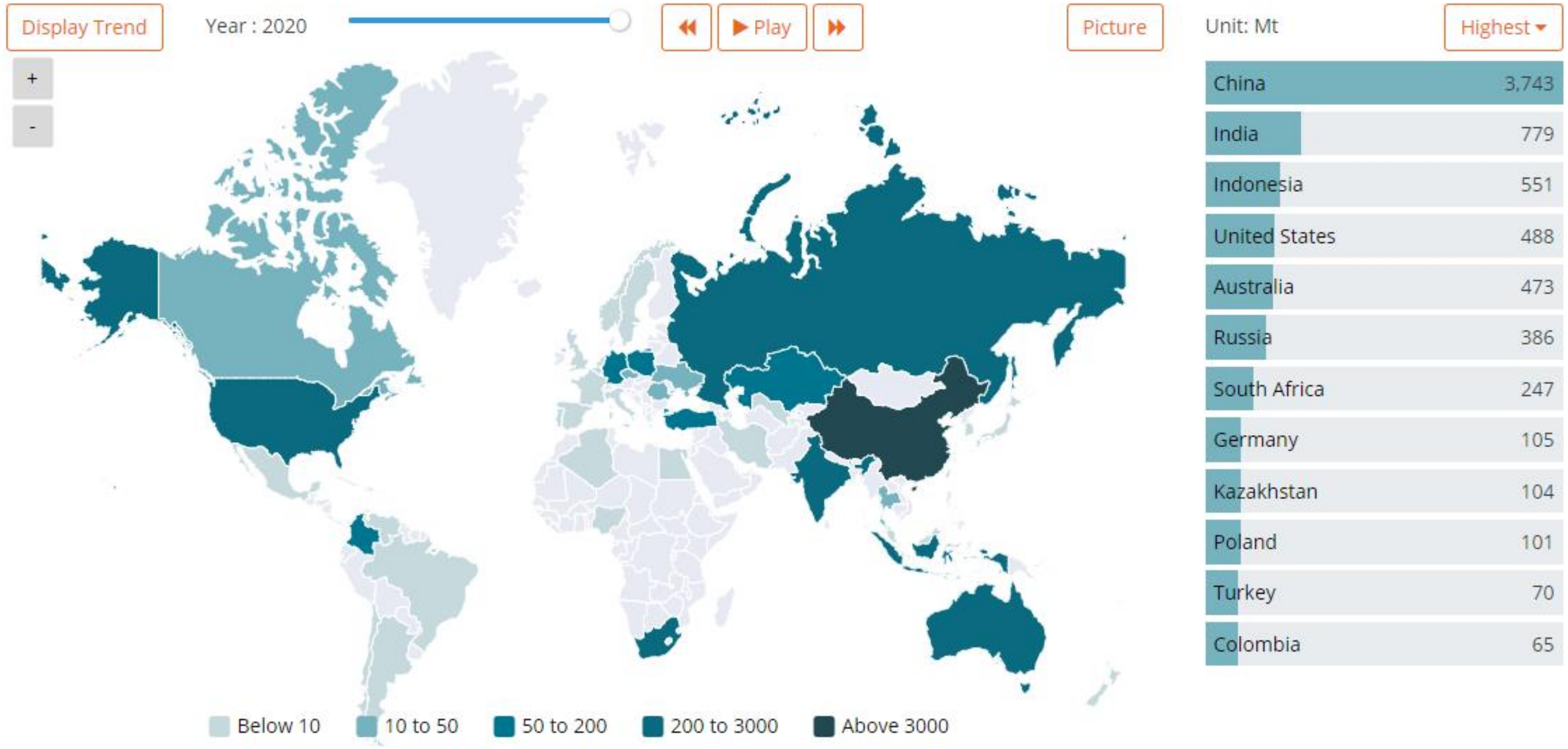
Methane in the Context of the Transition of the Coal Sector
27-28 September, 2021

DD-MET

UNECE Poland ICE-CMM Global Methane Initiative

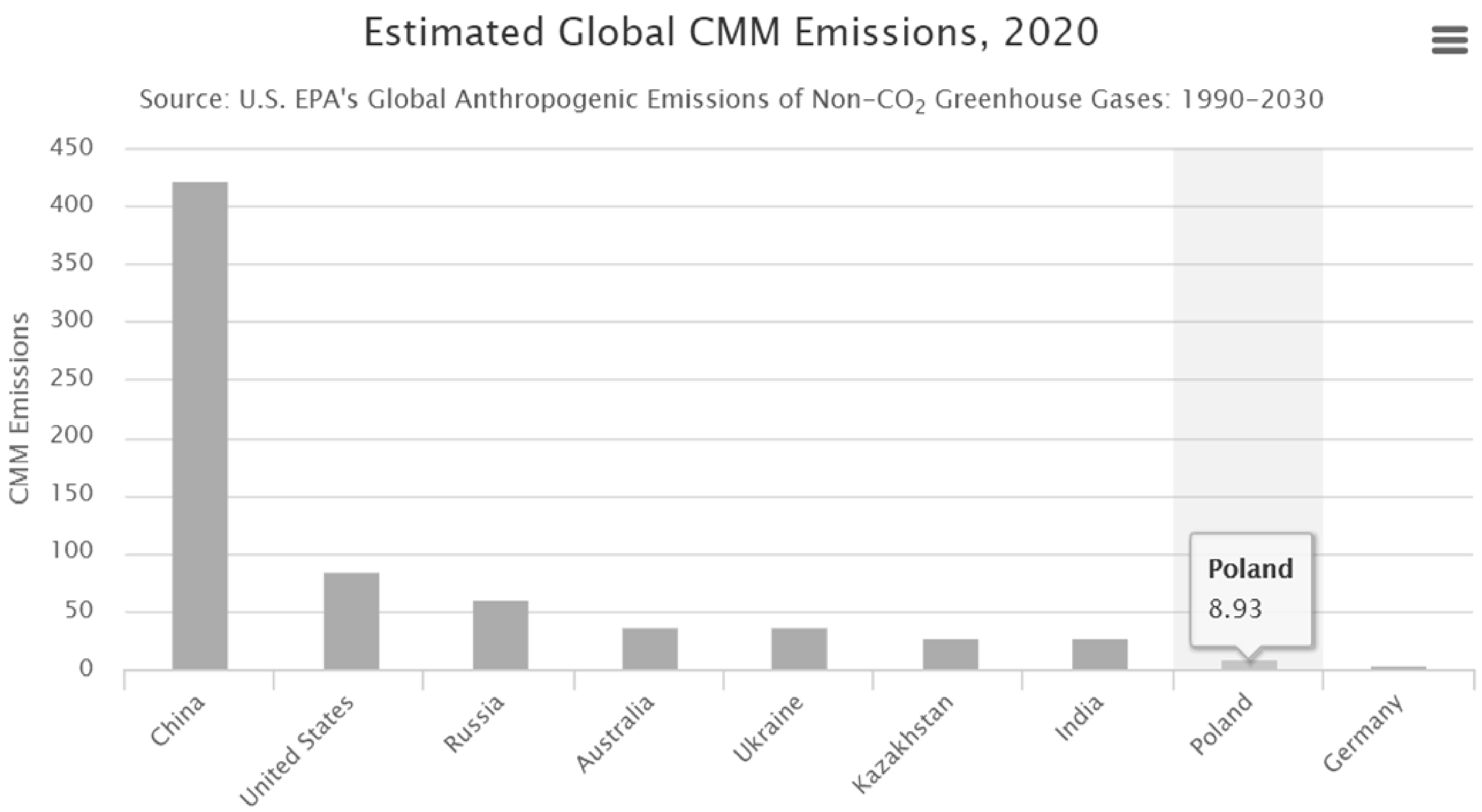
GIG POLSKA GRUPA GÓRNICZA Imperial College London ИПКОН

COAL PRODUCTION IN SELECTED COUNTRIES



*Source: https://yearbook.enerdata.net/coal-lignite/coal-production-data.html

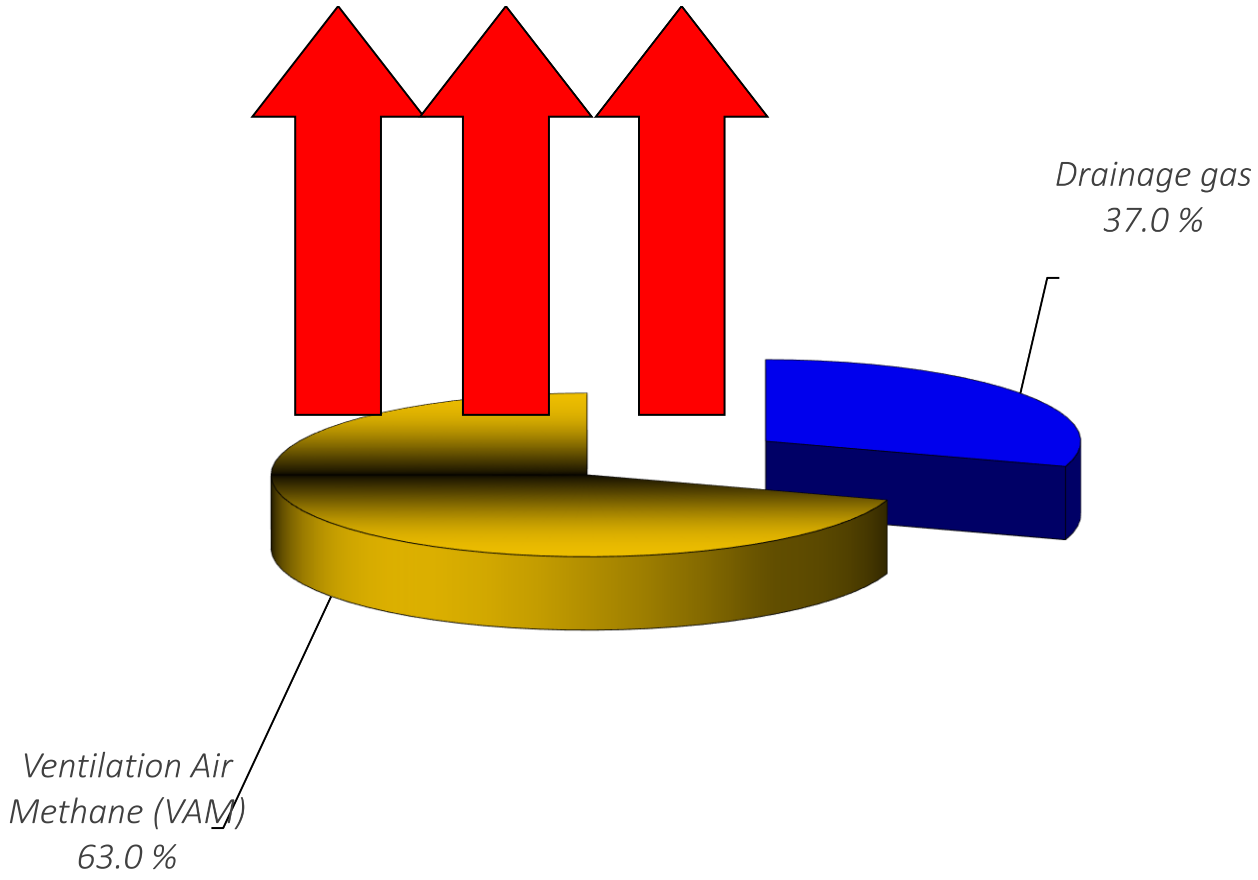
GLOBAL CMM EMISSIONS



Source: https://www.epa.gov/cmop/frequent-questions

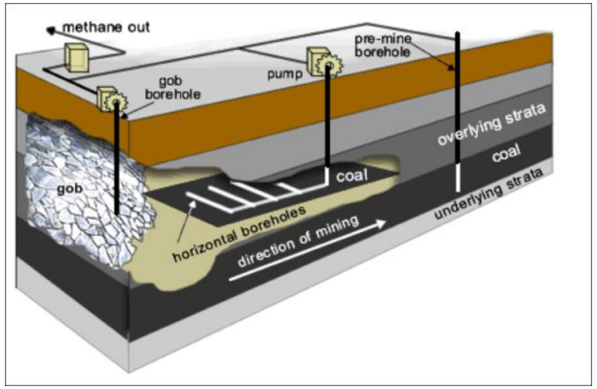
TOTAL GAS RELEASED DURING MINING OPERATIONS IN POLISH UNDERGROUND HARD COAL MINES

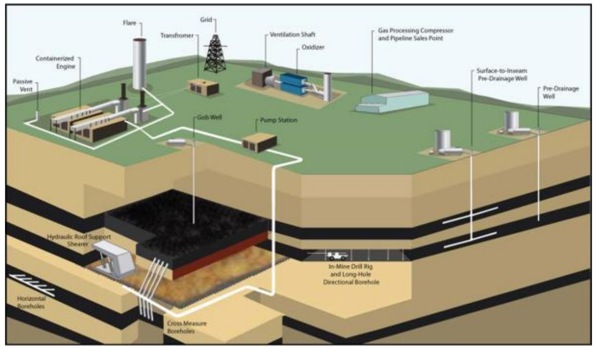
(about 819.6 mln m³) 803.8. mln m³ in 2019



MITIGATION OF CMM EMISSIONS:

- *CBM opeations (ahead of mining)*
- *Underground drainage*
- *Utilisation of VAM*





EPA-400-D-09-001

Swick Mining Services Limited

Fortman Clean Energy Technology Ltd VAM Abatement Project, Gaohe Mine, Shanxi Province, China

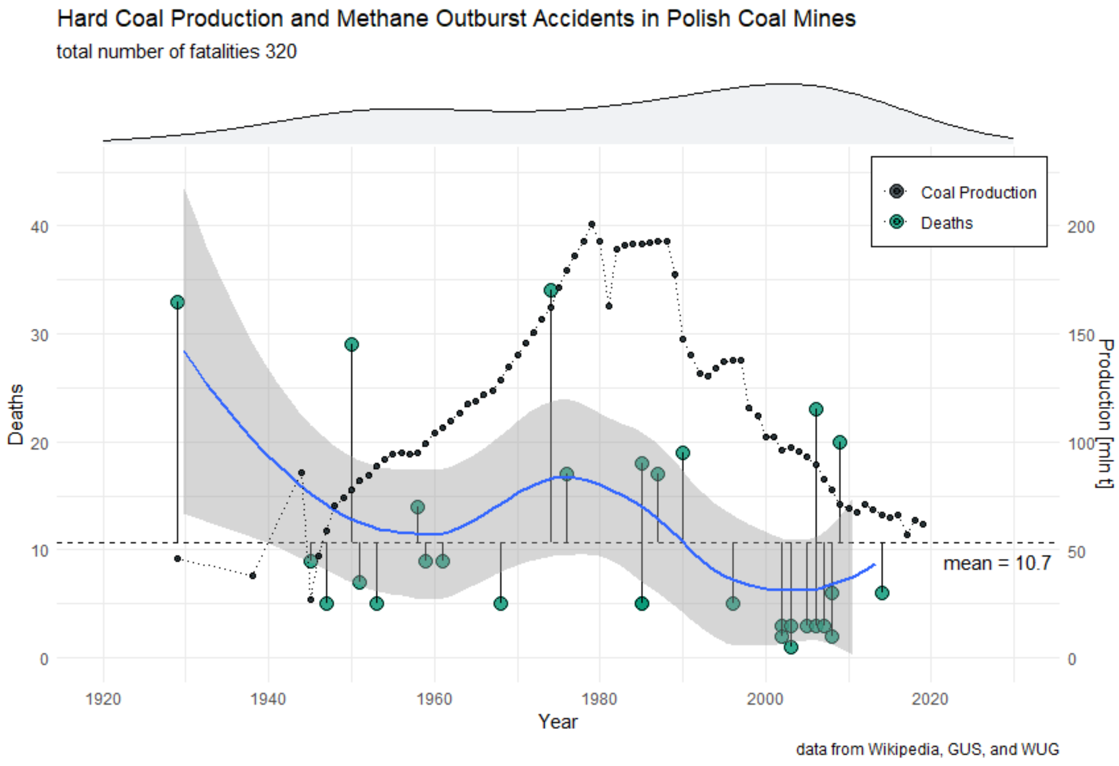
Biothermica VAMOX™, Blue Creek Mine #4 Mine, Alabama, USA

*EPA-430-F-19-023 Ventilation Air Methane (VAM) Utilization Technologies, July 2019

MOTIVATION

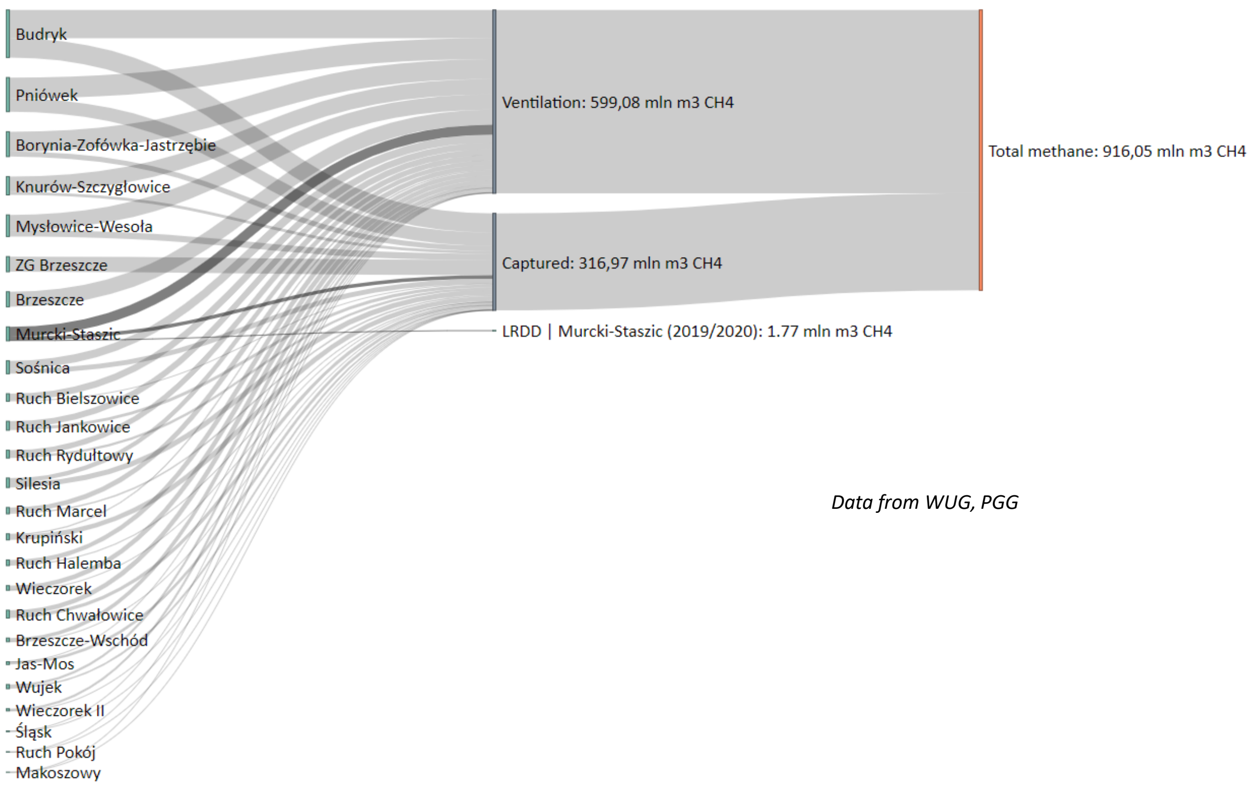
Reduce GHG emissions

Improve safety and productivity



CMM released and captured during mining operations in 2018

Methane drainage efiiciency 34.6%



Data from WUG, PGG

Specification	Year										
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Absolute methane bearing capacity (million m^3/year)	834.9	828.8	828.2	847.8	891.2	933.0	933.8	918.7	916.1	803.8	819.6
Methane drainage (million m^3/year)	255.9 30.65%	250.2 30.19%	266.7 32.20%	276.6 32.63%	321.1 36.03%	338.97 36.33%	342.1 36.64%	324.9 35.37%	317 34.60%	301.6 37.50%	302.8 37.00%
Amount of economically utilized methane (million m^3/year)	161.1 19.30%	166.3 20.07%	178.6 21.56%	187.7 22.14%	211.4 23.27%	197.09 21.12%	195.0 20.88%	209.1 22.76%	203.1 22.1%	189.4 23.5%	187.9 23.0%
Number of the hard coal mines	32	31	31	30	30	30	23 (34 plants)	21 (27 plants)	20 (30 plants)	20 (30 plants)	17 (23 plants)
Hard coal output (Mt)	76.1	75.5	79.2	76.5	72.5	72.2	70.4	65.8	63.4	61.6	54.4

METHANE DRAINAGE CONSIDERATIONS

Geologic characterization

Reservoir characterization

Source of gas emissions

Mining technique

Operation time schedule/mining activity

Drainage approach/techniques

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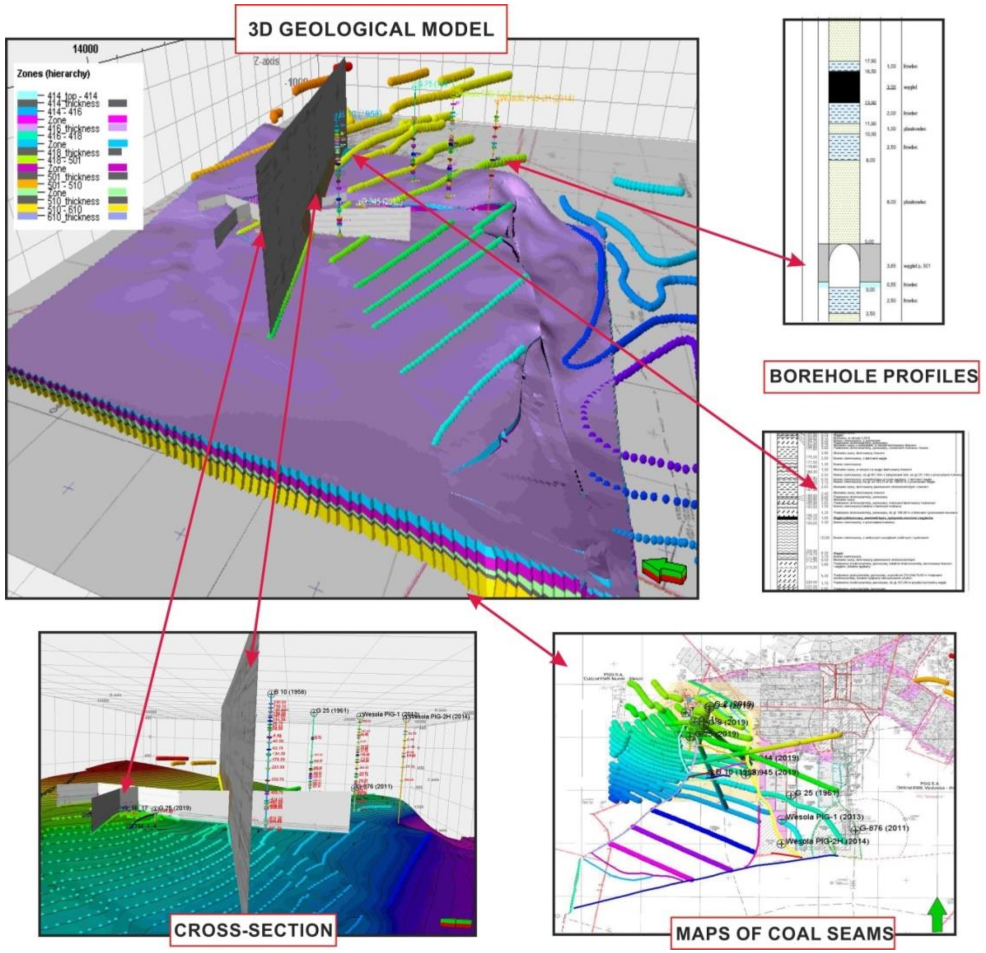


METHANE CONTROL STRATEGIES

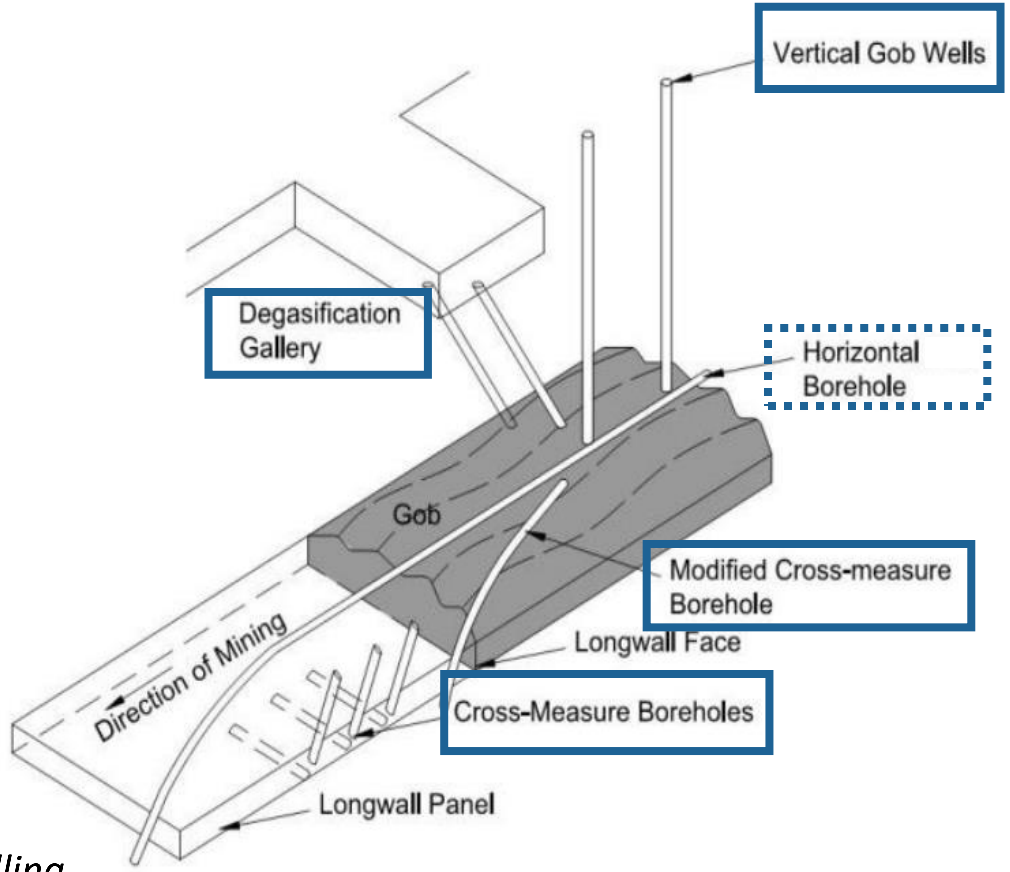
- dilution to safe concentrations with the ventilation system
- capturing in boreholes gas drainage galleries

drainage before (pre-mining) and/or during coal exploitation

CONVENTIONAL

ALTERNATIVE (new)

The strategy for gas control varies among different mines. In some coal mines the methane release at the operating longwall can be effectively managed using a ventilation air system. In gasses coal mines, however usually a combination of drainage and ventilation must be used.



REI Drilling

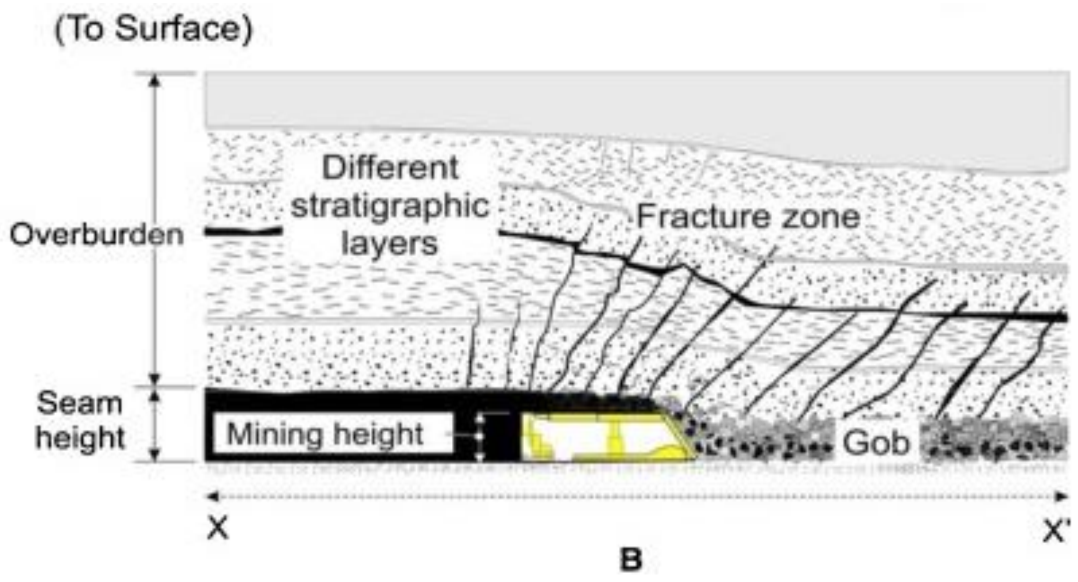
LONG REACH DIRECTIONAL DRILLING

LRDD can operate in-seam cross a seam or be a combination of both

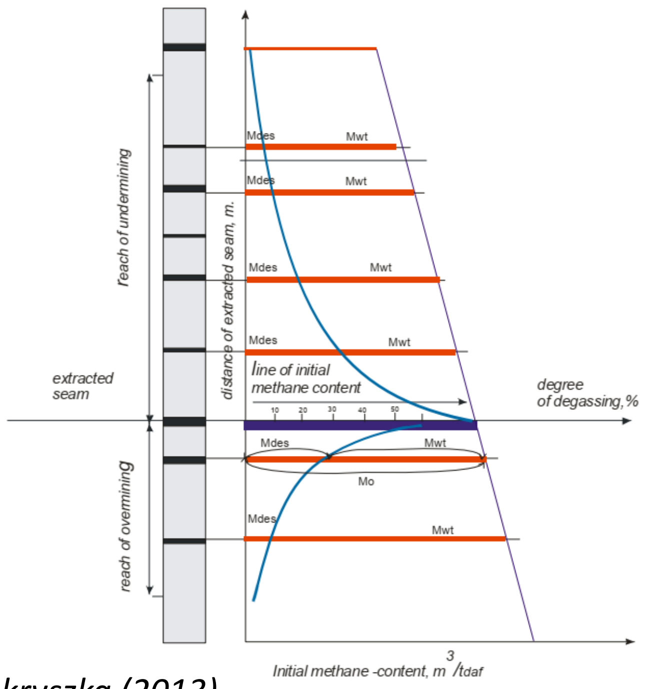
Drilled above the coal panel into the fractured zone (inside coal or sandstone) but above strata relaxation zone and gob zone

The rate of methane release in disturbed strata depends on:

- gas content
- thickness of disturbed coal seams
- strength of coal-bearing strata
- coal seam permeability
- rate of coal production
- the geometry of mine workings
- and mine design
- geology



Karacan (2008)



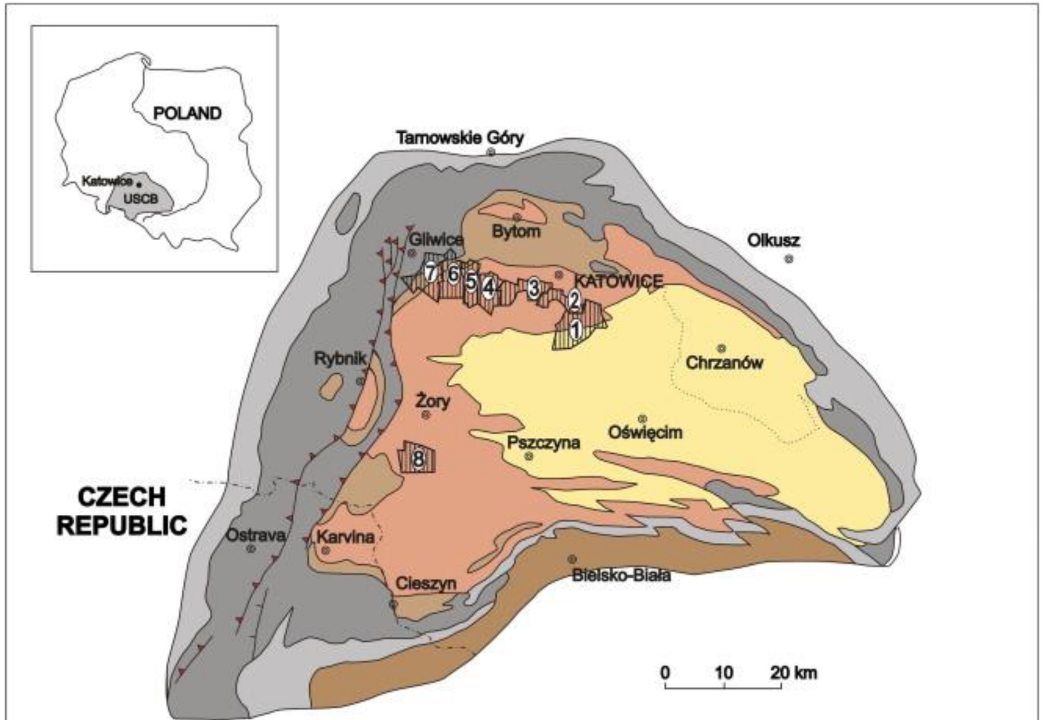
Krause and Pokryszka (2013)

DD-MET PROJECT GANTT CHART

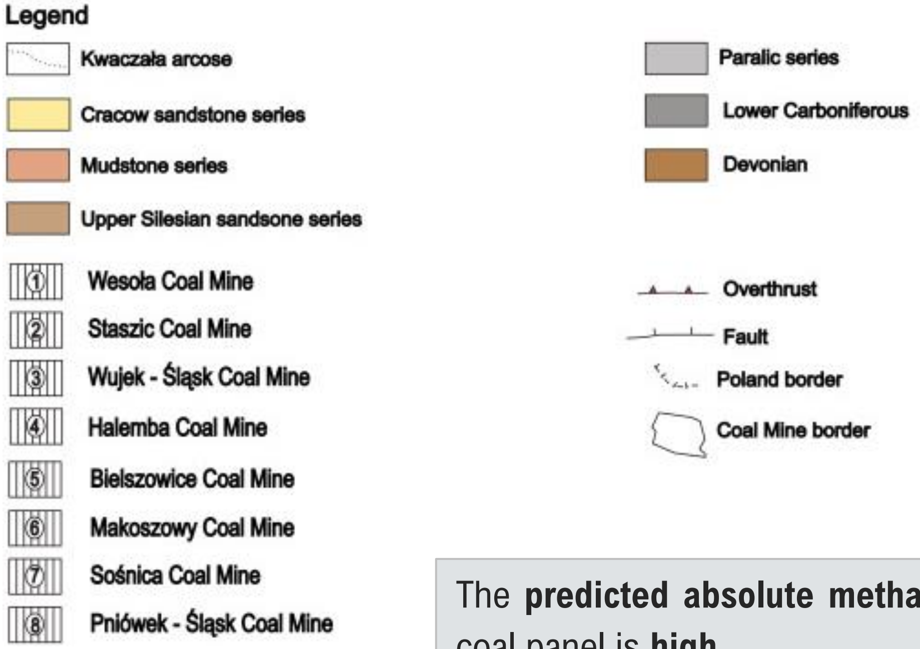
28.09.2021

Work packages	Work packages' title	1st Year		2nd Year				3rd Year				4th Year				5th Year			
		III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
WP 1	**COORDINATION AND REPORTING**																		
Task1.1	Administration																		D1
Task 1.2	Technical Co-ordination		D2																
Task 1.3	Co-ordination and partnership level																		
Task 1.4	Co-ordination of knowlage management																		
WP 2	**LABORATORY AND FIELD EXPERIMENTS (Characterisation of coal seams and rock)**				M1				M2			M3 M4							
Task 2.1	Evaluation of the initial conditions of the analyzed coal seam taking into account mining activity in its surroundings							D3				D4							
Task 2.2	Characterisctics of the gas-coal system											D5							
Task 2.3	Laboratory experiments																		
Task 2.4	Measurement of prevailing stress and geomechanical parameters											D6							
WP 3	**NUMERICAL MODELING AND SIMULATIONS**													M5			M6		
Task 3.1	Geological data integration and interpretation																		
Task 3.2	Development of structural models and 3D models of petrophysical and geomechanical properties												D7						
Task 3.3	Development of geomechanical models of stress fields and resulting deformations														D8				
Task 3.4	Construction, initialization and calibration of dynamical simulation models																		
Task 3.5	Assessment of the drainage strategy performance and optimization of its parameters																D9		
WP 4	**FIELD SCALE DEMONSTRATION AND IMPLEMENTATION**															M7 M8		M9	
Task 4.1	Technology development, Technical design and drilling of long directional boreholes													D10					
Task 4.2	Evaluation of geomechanical stability															D11			
Task 4.3	Long-term monitoring and assessment																	D12	
WP5	**RISK ASSESSMENT**												M10						
Task 5.1	Potencial failure mode analysis													D13					
Task 5.2	Environmental risk assessment																	D14	
WP6	**PRE-FEASIBILITY STUDY, LCA ANALYSIS AND ECOEFFICIENCY ANALYSIS**																	M11 M12	
Task 6.1	Data inventory													D15					
Task 6.2	Pre-feasibility study																	D16	
Task 6.3	Life cycle assessment (LCA)																	D17	
Task 6.4	Ecoefficiency analysis																	D18	
WP7	**CONCLUSIONS, RECOMMENDATIONS AND DISSEMINATIONS**																		M13
Task 7.1	Dissemination workshop																		D19
Task 7.2	Lessons learned document																		D20
Task 7.3	Publications																		

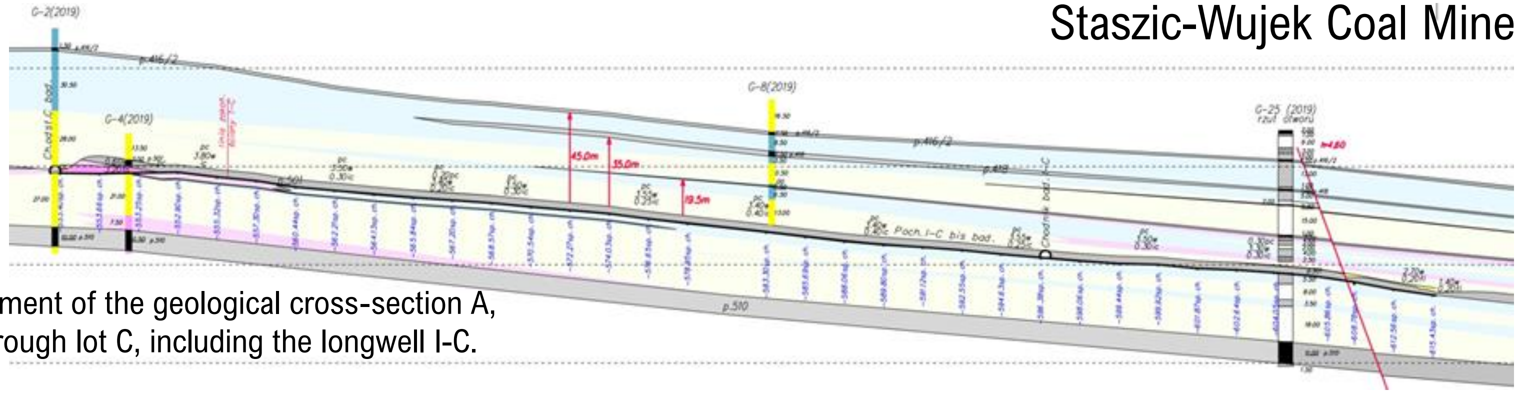
AREA OF INVESTIGATION



Fabiańska et al., 2013



Staszic-Wujek Coal Mine



Segment of the geological cross-section A, through lot C, including the longwell I-C.

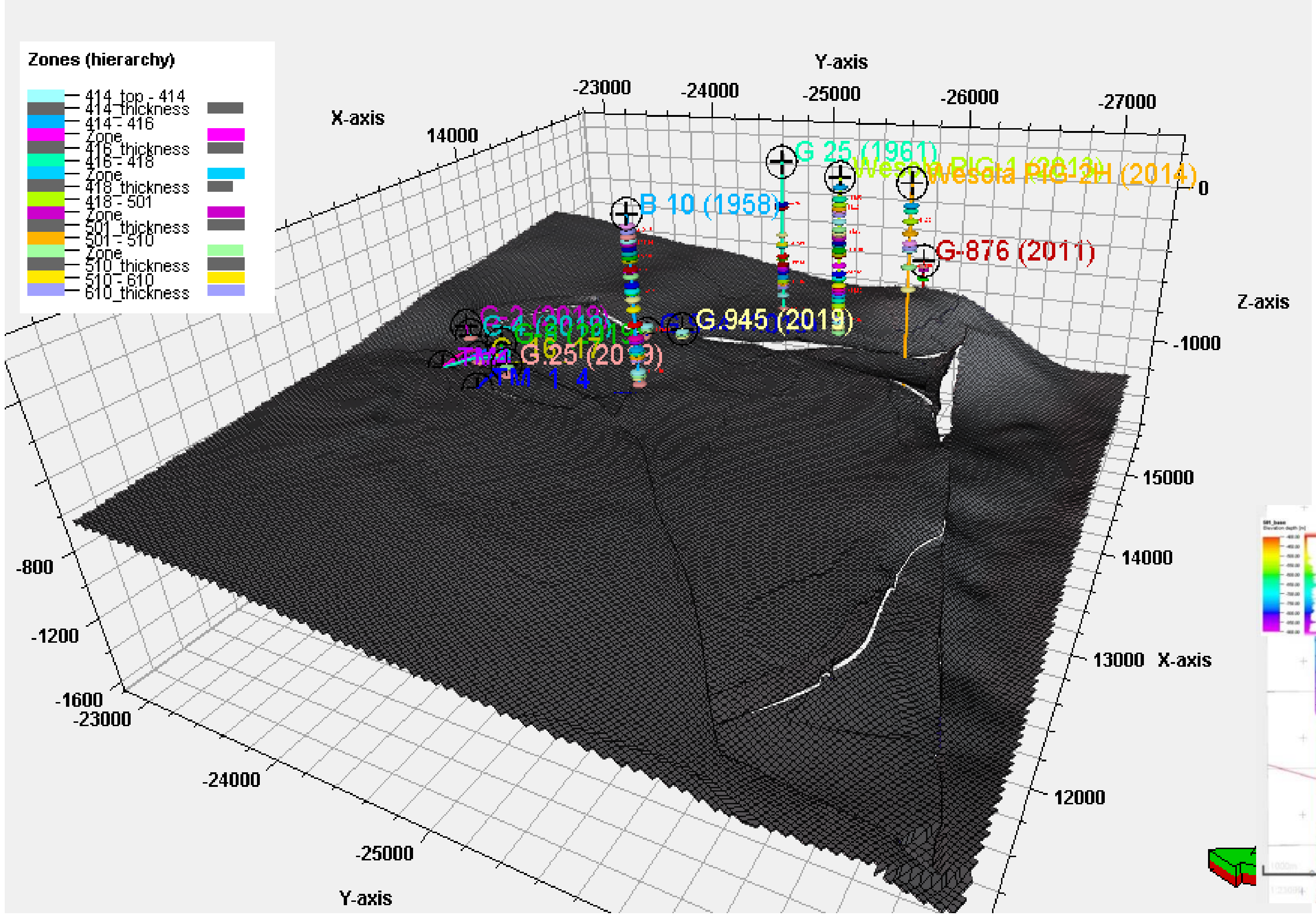
The **predicted absolute methane capacity** of the I-C coal panel is **high**,

The value of the calculated criterion methane bearing capacity is lower than the estimated absolute methane bearing capacity for the longwall progress **6.0/day**, the **maximum** value of which **is 26.07 m^3 CH_4/min**, which **implies the use of methane drainage**

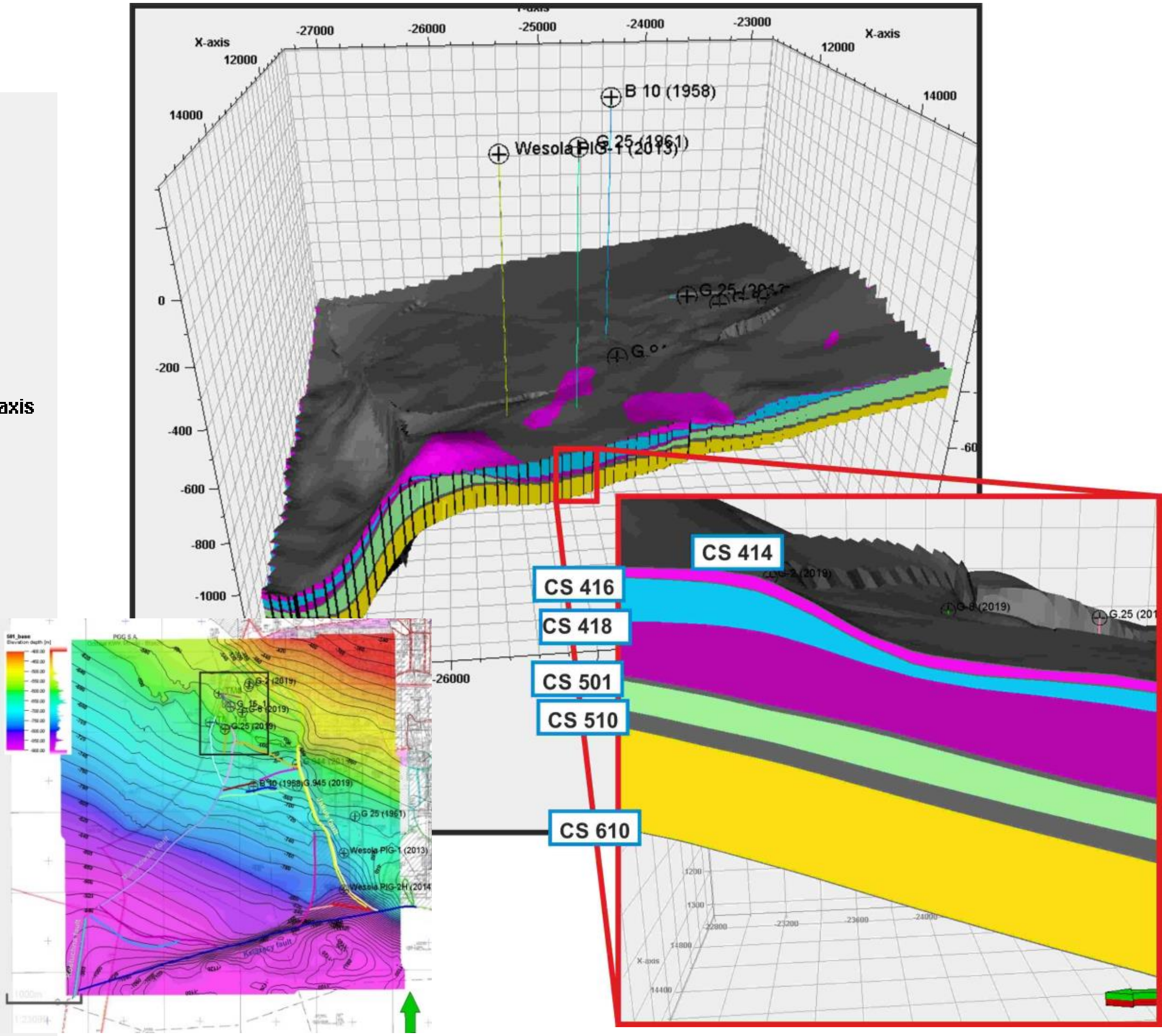
Mine experience acquired during the operation of coal panels in the **IV category of methane hazard**

AREA OF INVESTIGATION

Structure of 501 CS



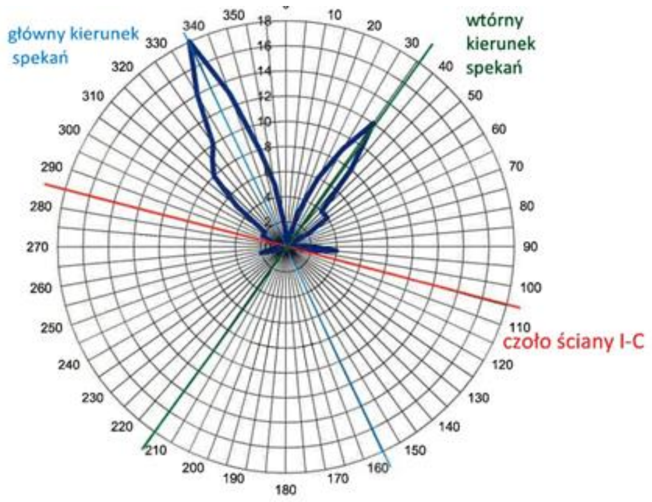
Horizontal resolution 25 x 25 m

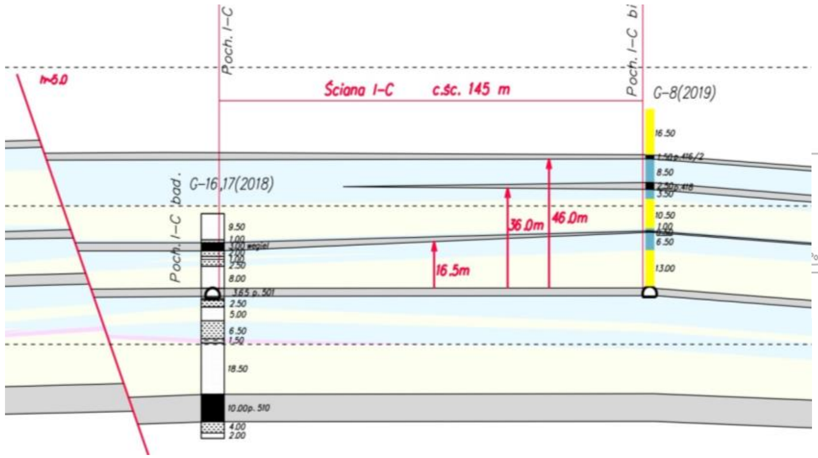


Structural model of the strata between 610 and 414 coal seams

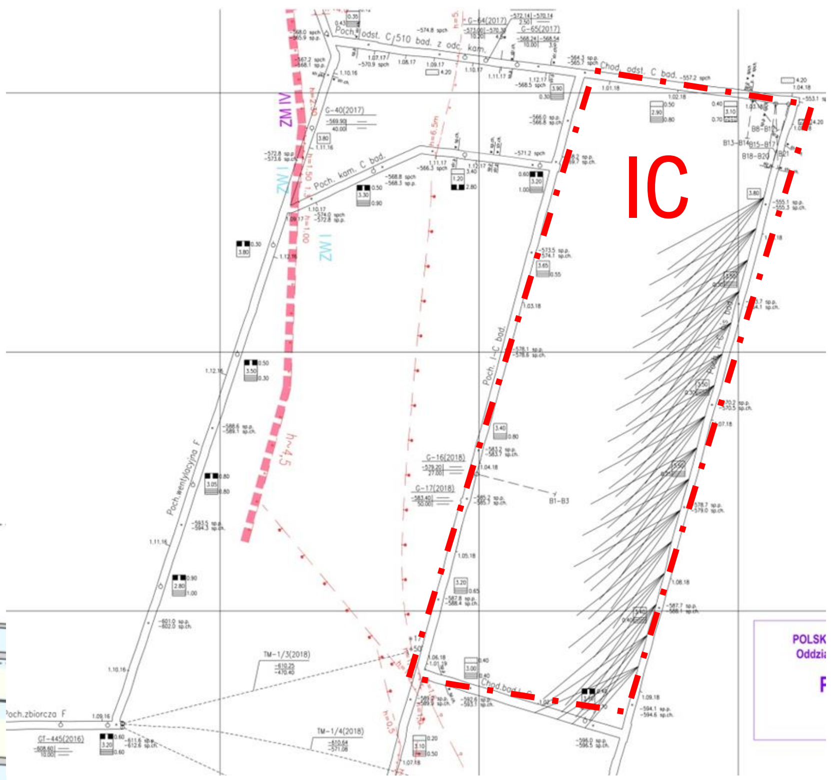
LOCATION AND TRAJECTORIES OF METHANE DRAINAGE BOREHOLES

"Fractures' rose" diagram

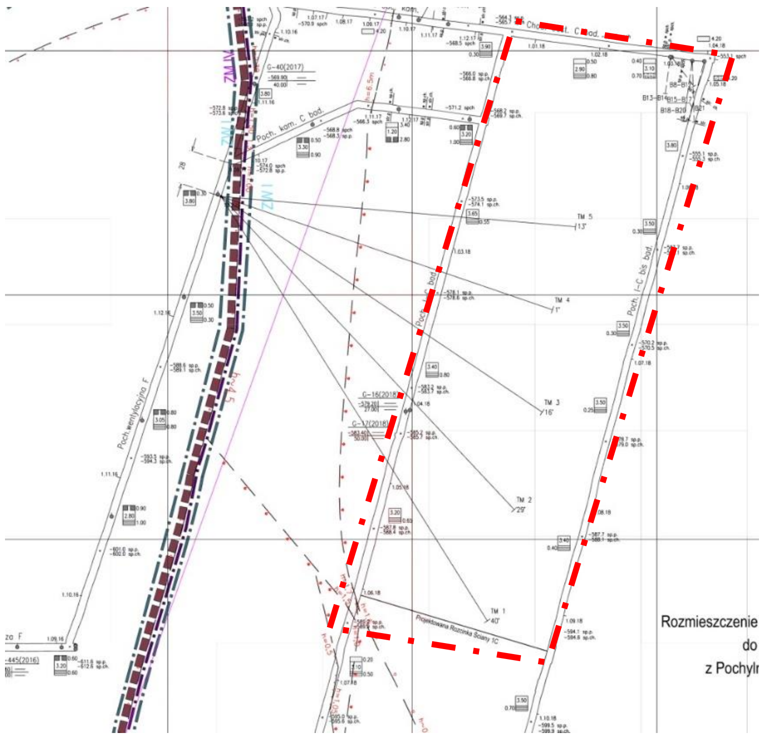




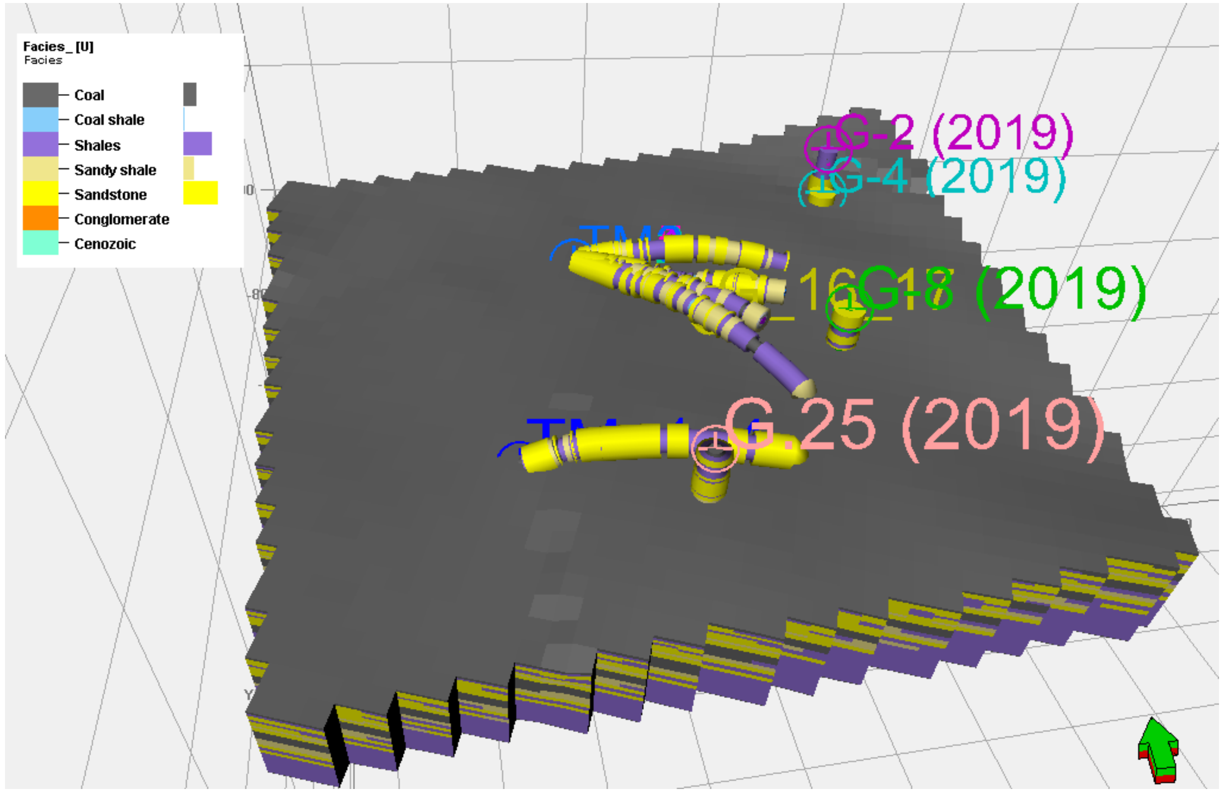
CONVENTIONAL

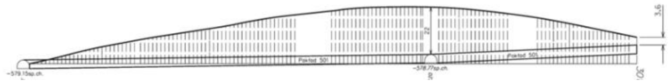


LRDD

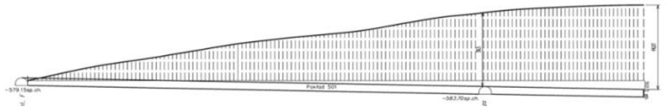


LOCATION OF LRDD WELLS



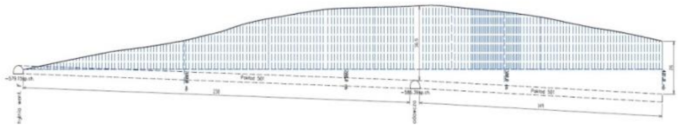


Bore hole nº TM 5. length: 302 m

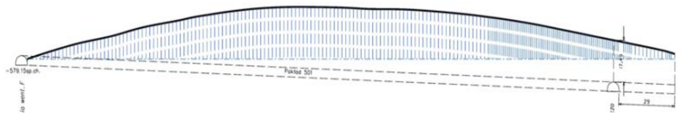


Bore hole nº TM 4. length: 301 m

Bore hole nº TM 3. length: 300 m



Bore hole nº TM 2. length: 401 m



Bore hole nº TM 1a. length: 402 m

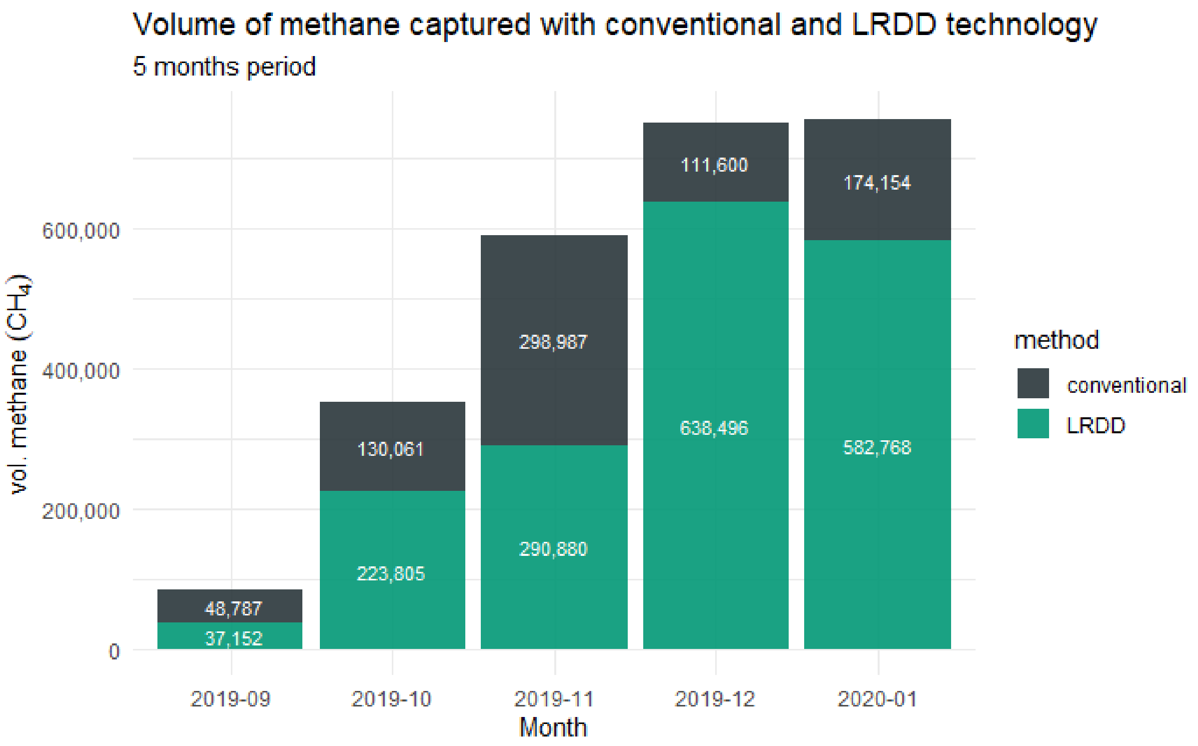
Borehole	Vertical output angle	Total length (m)	Length in coal (m) | (% of total length)	Maximum production rate (m^3/min)	Face position vs maximum production rate
TM1a	+ 16°	402	42.0 | (10.4)	2.0	/
TM2	+ 8°	401	39.1 | (9.8)	7.1	24 m behind the faceline
TM4	+ 16°	302	18.3 | (6.1)	5.2	56.5 m behind the faceline
TM3	+ 6°	300	29.3 | (9.8)	4.1	29 m behind the faceline
TM5	+ 16°	301	10.5 |(3.5)	4.9	18 m in front of the faceline

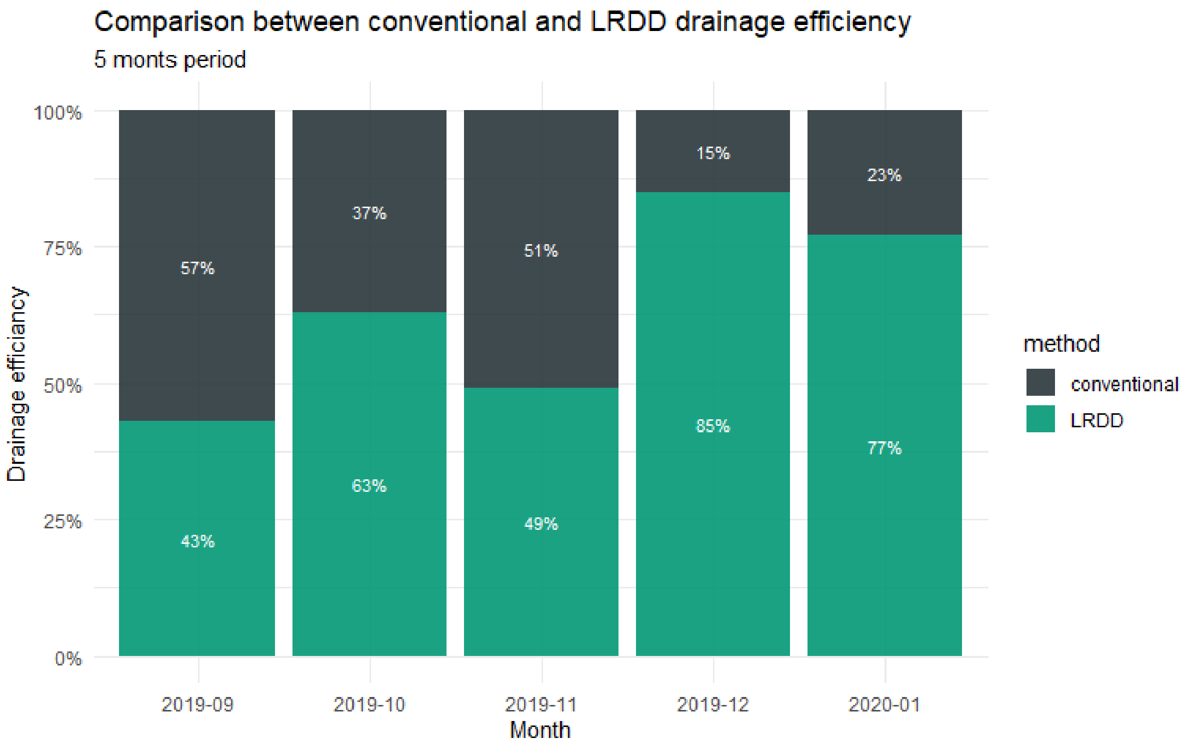
DRAINAGE EFFICIENCY

Conventional: 763 588.8 m^3 CH_4 (30.1%)

LRDD: 1 773 100.8 m^3 CH_4 (69.9%)

SUM: 2 536 689.6 m^3 CH_4

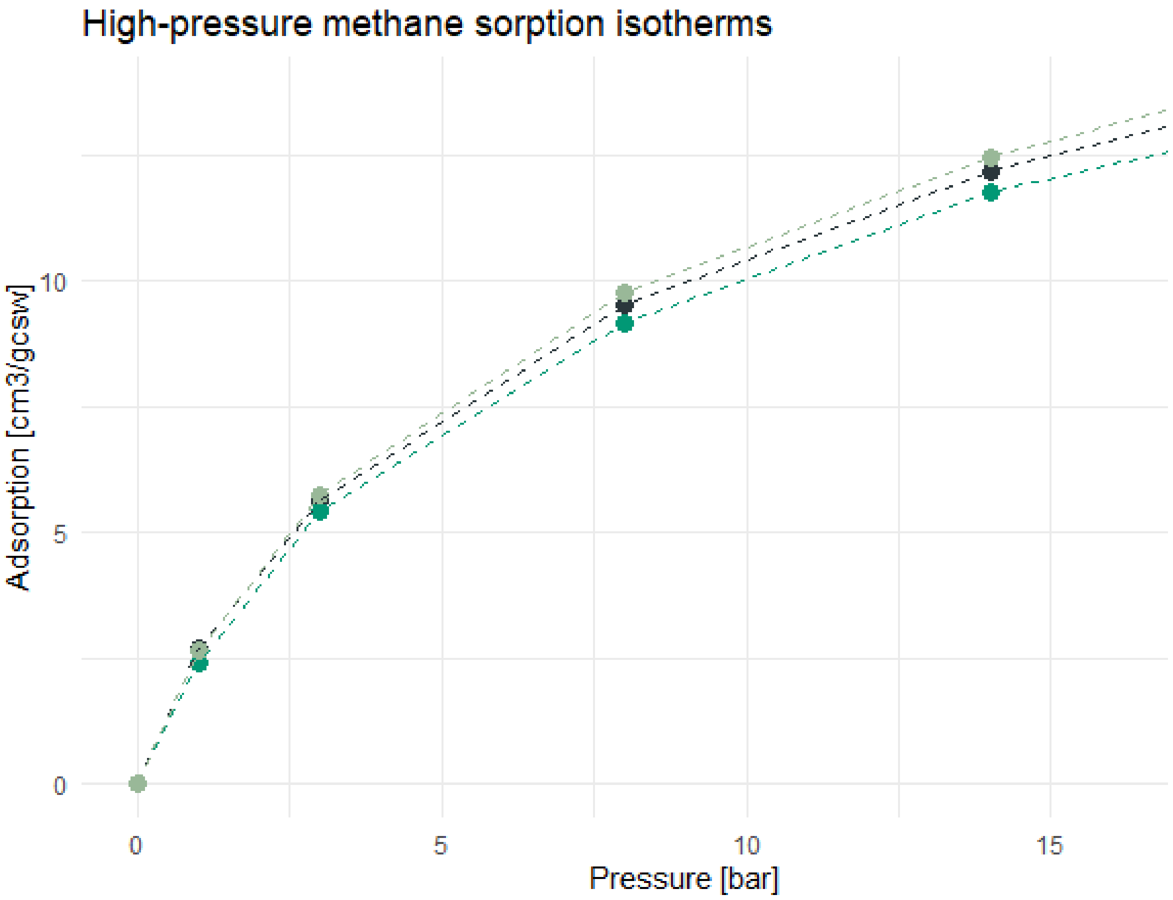




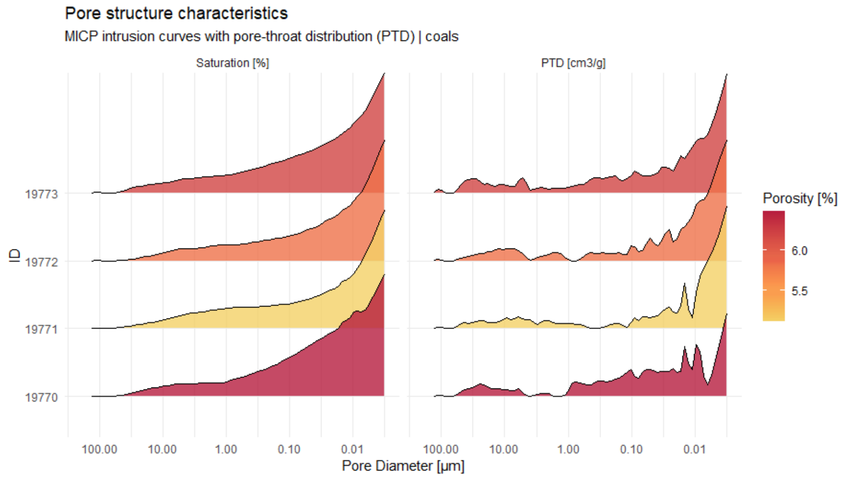
COAL PROPERTIES

SORPTION ISOTHERMS (selected samples)

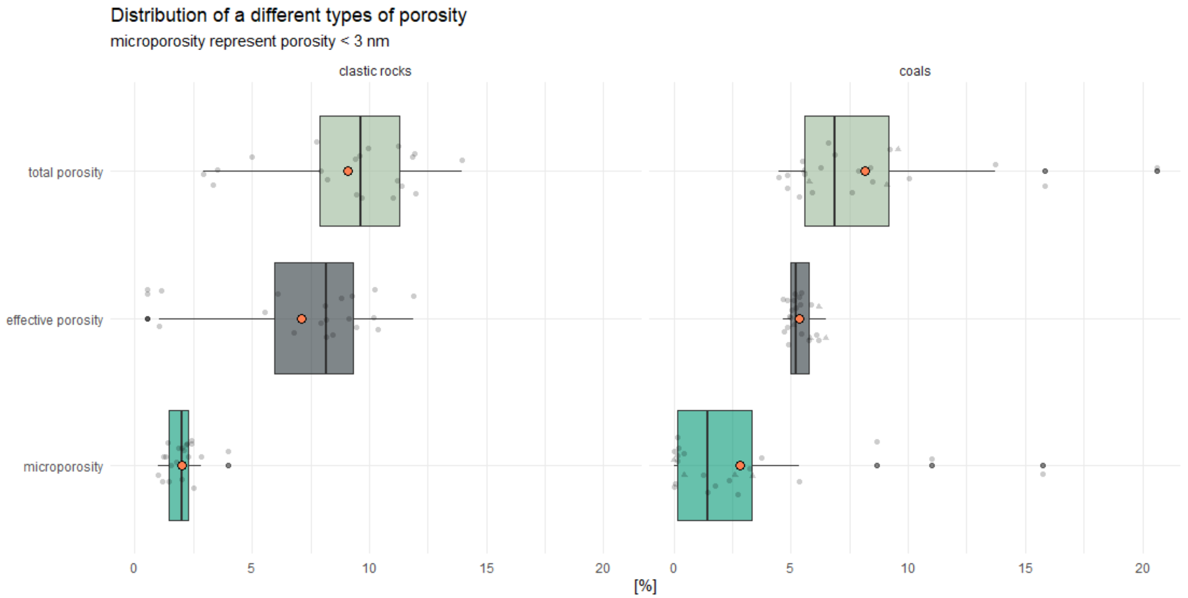
- Methane-bearing capacity test
- Chromatographic analysis
- Physico-chemical parameters
- (hygroscopic moisture content - Wh, ash content - A, volatile matter content – Vdaf)
- Sorption isotherms
- (sorption capacity, sorption capacity in reference to daf, effective diffusion coefficient, and half-time sorption)

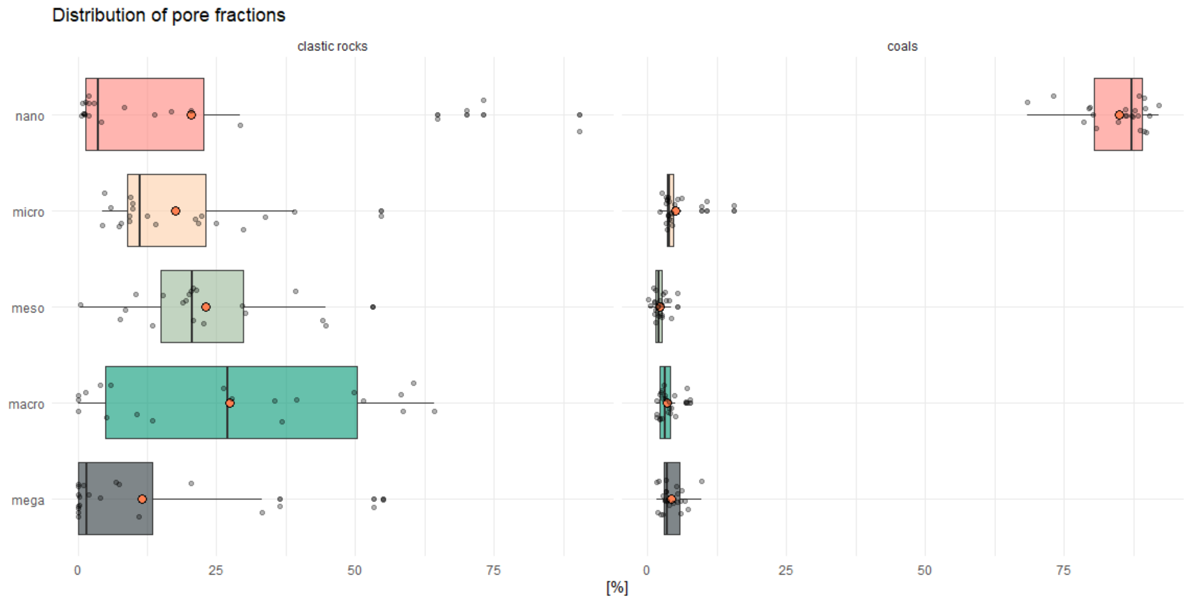


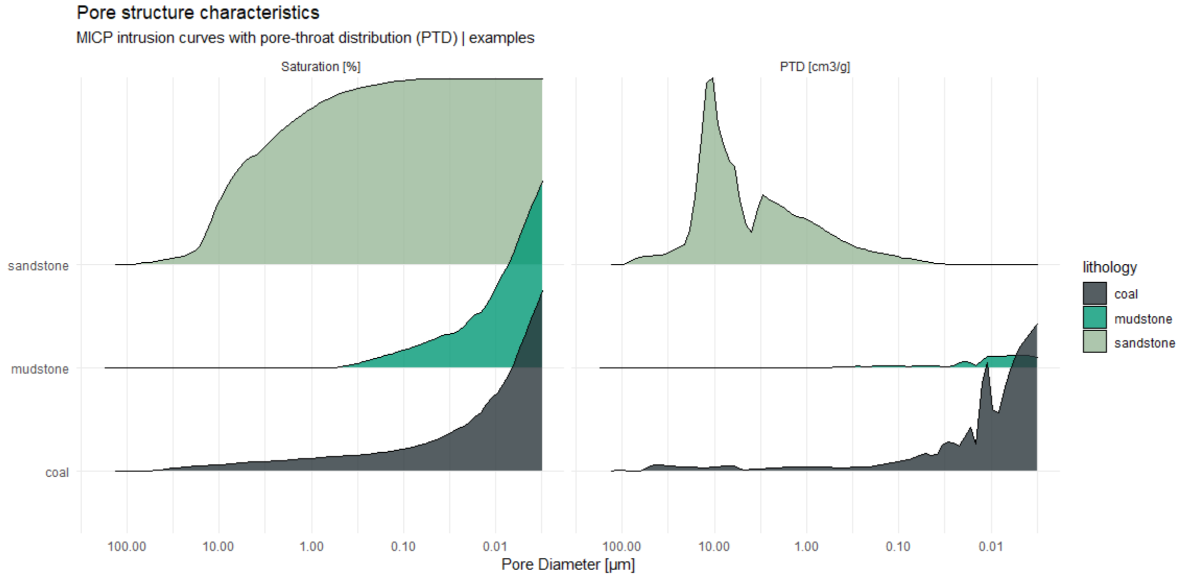
The sorption isotherms for the indicated pressures are similar, which is also reflected in similar pore structure of the analyzed coal samples



COAL PROPERTIES *PORE STRUCTURE*



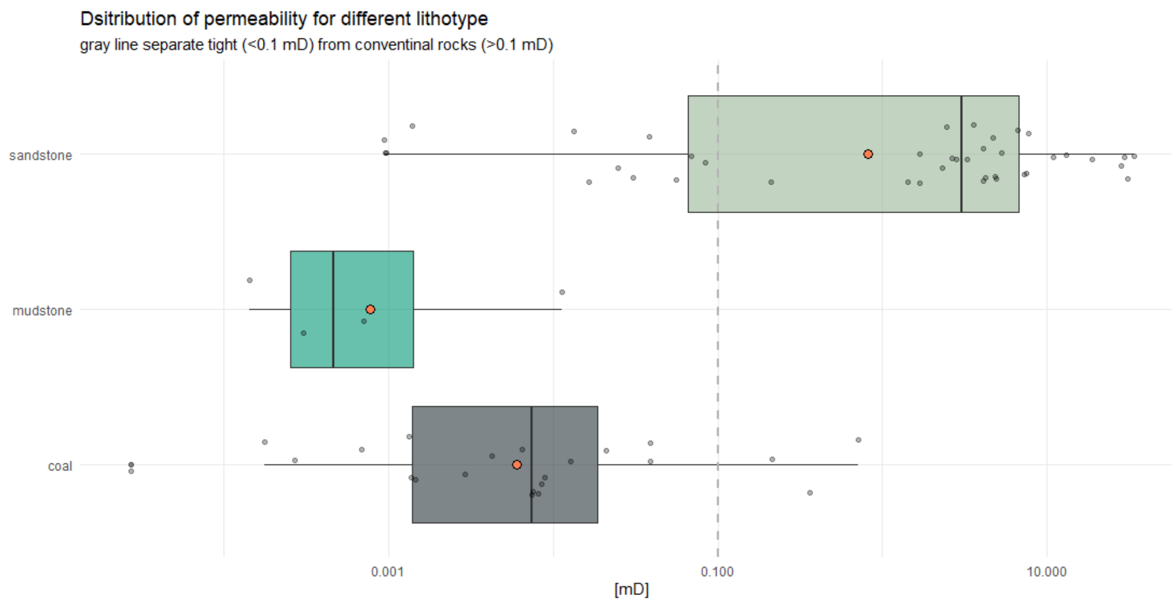


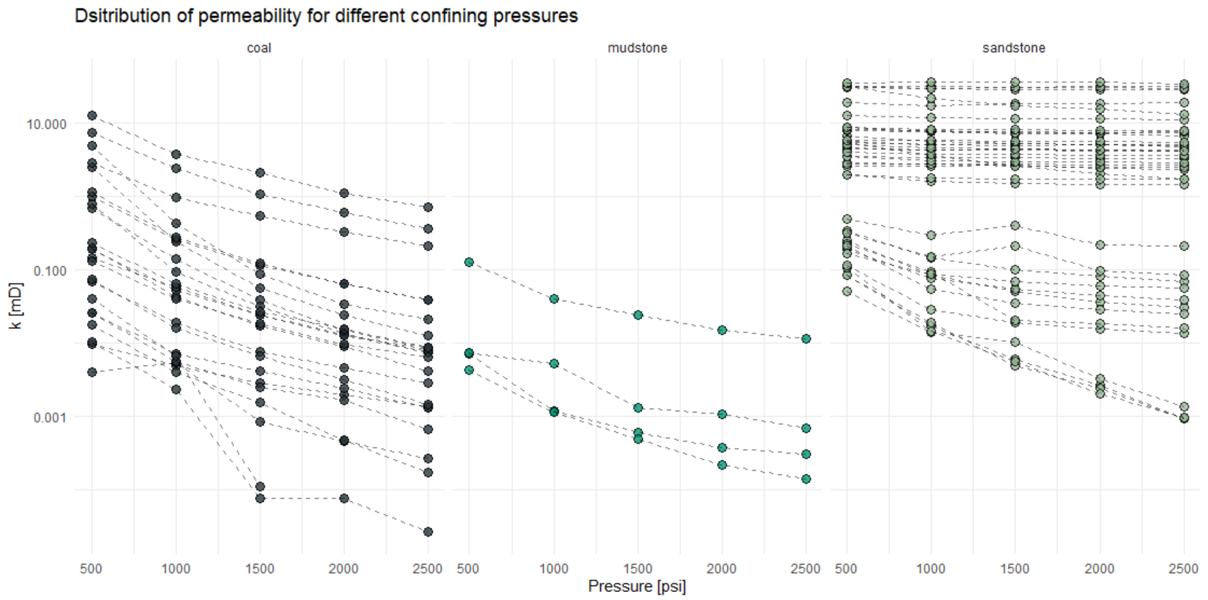


The total porosity for clastic rock is moderate with median at about 10%. For coal samples the median of total porosity is about 6%.

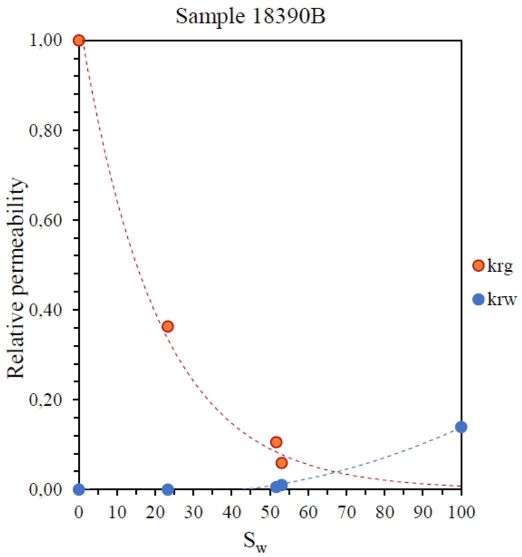
Clastic rocks are dominatd by macropores (2-10 um) while coals are almost completedy dominated by nanopores (<0.1um)

COAL PROPERTIES *FILTRATION PROPERTIES*





2 rock-types of sandstone samples



k_{abs} = 10.22 mD

$\phi_{effective}$ = 9.25 %

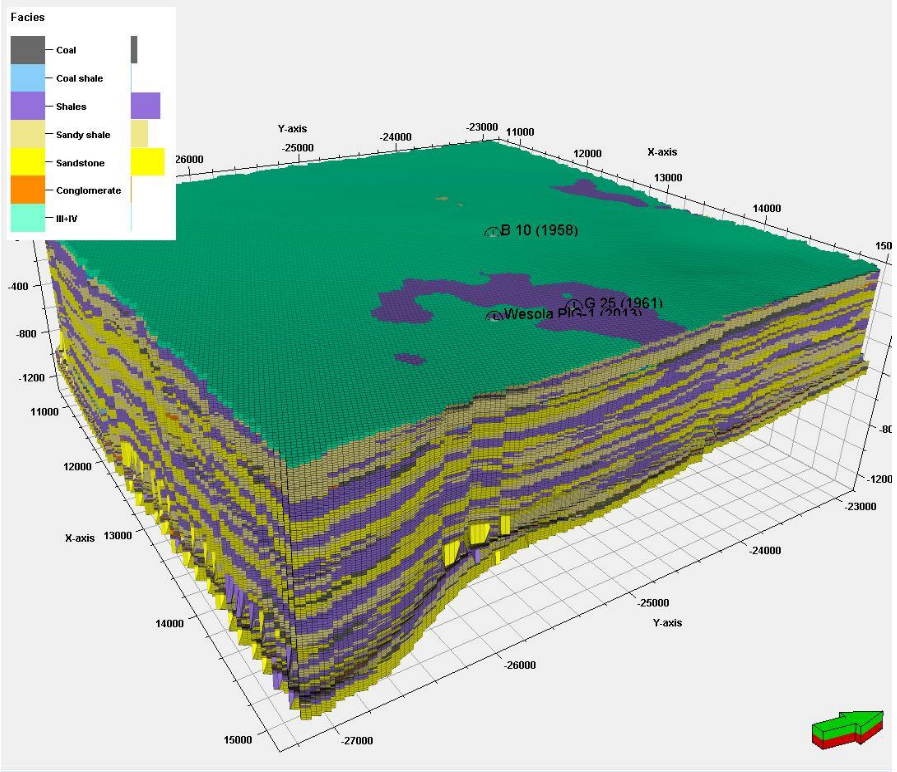
ϕ_{total} = 11.24 %

S_w	K_{rg}	K_{rw}
0.00	1.00	-
23.26	0.36	0.000
51.66	0.11	0.006
53.02	0.06	0.010
100.00	-	0.139

The examinated sandstones show strongly water-wet conditions. Such type of curves suggests conditions which will facilitate gas flow

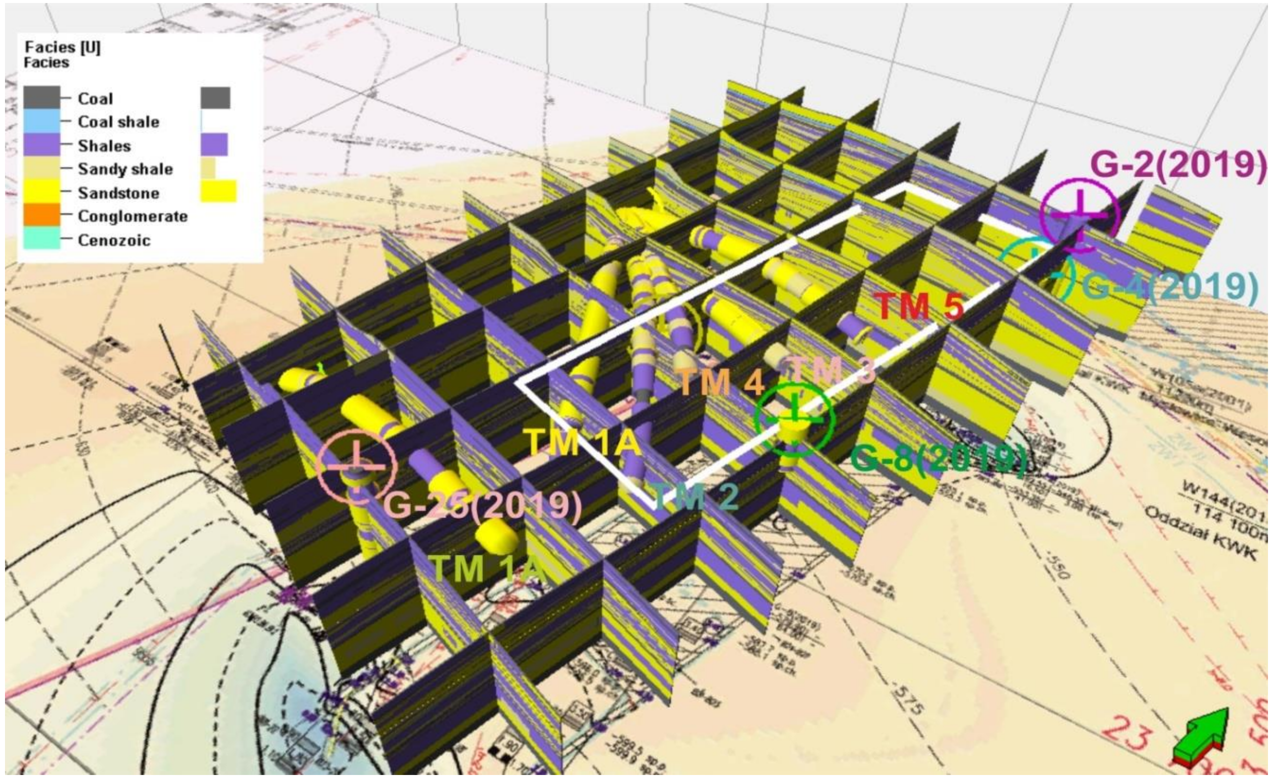
GEOLOGICAL MODELLING *LITOTHYPES*

Geostatistical analysis



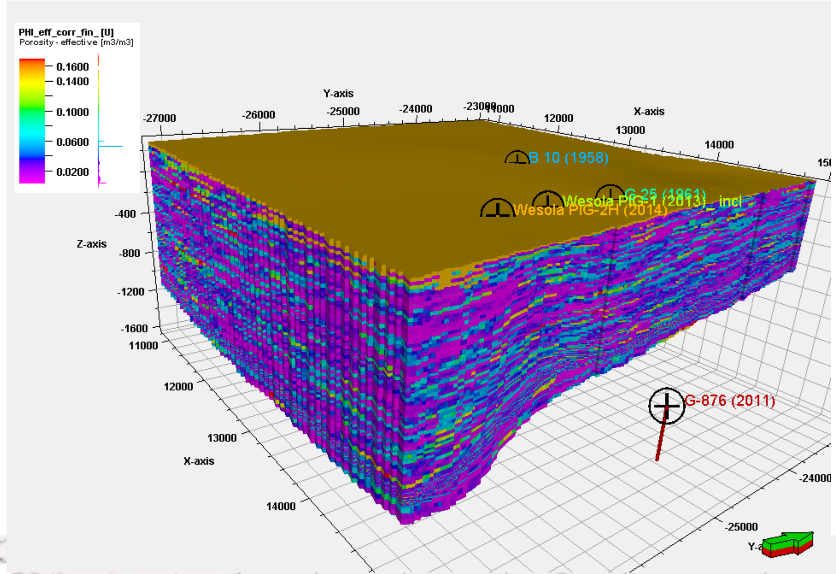
Horizontal resolution 25 x 25 m

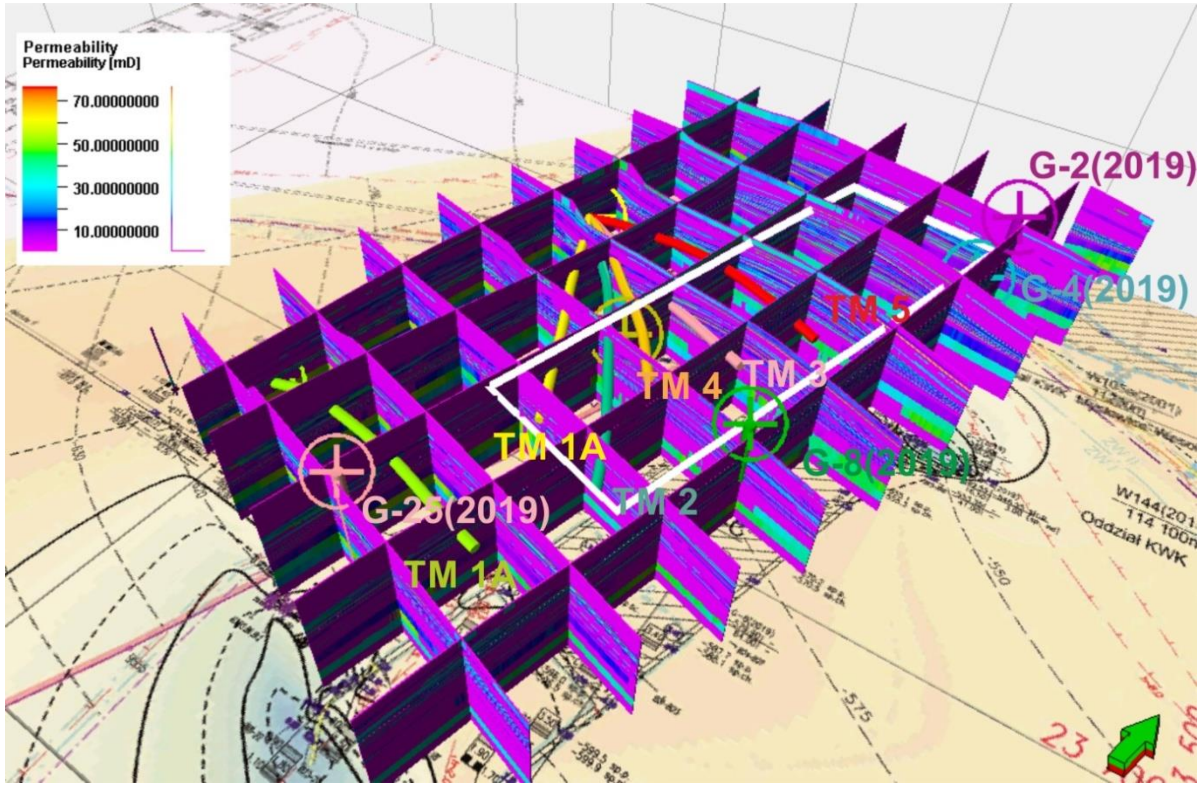
3D model of lithotypes occuring in the drainage area



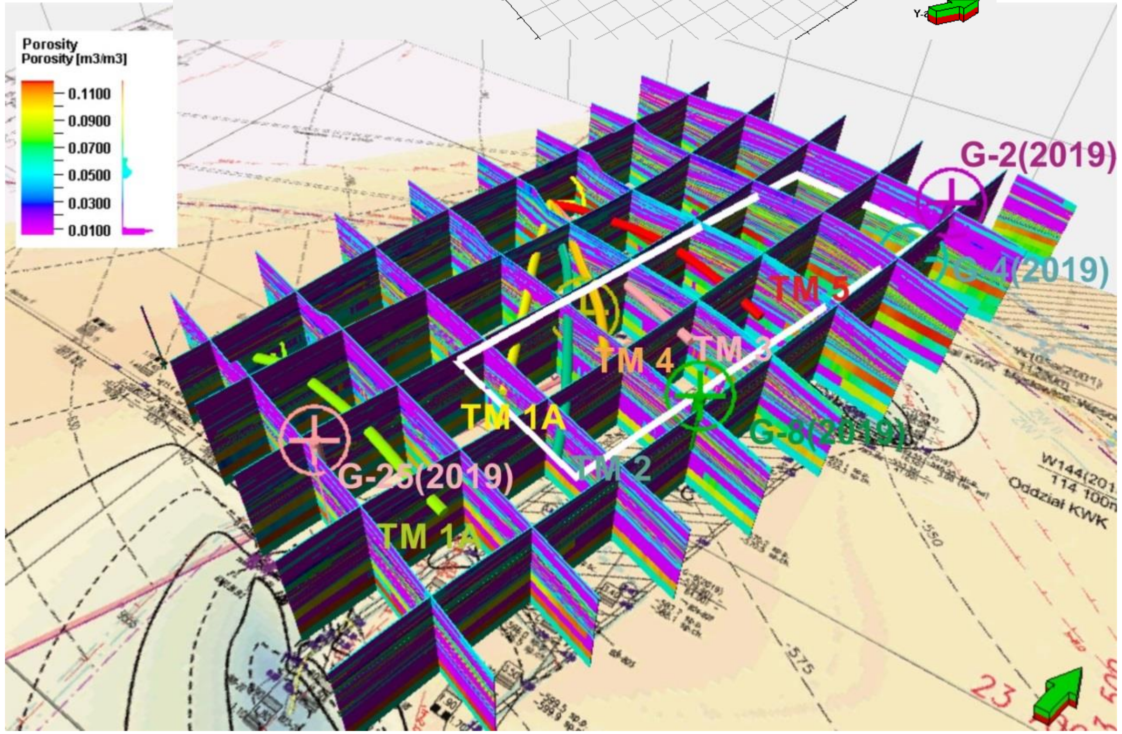
Horizontal resolution 1 x 1 m

GEOLOGICAL MODELLING PHI/K





3D permeability model in the drainage area

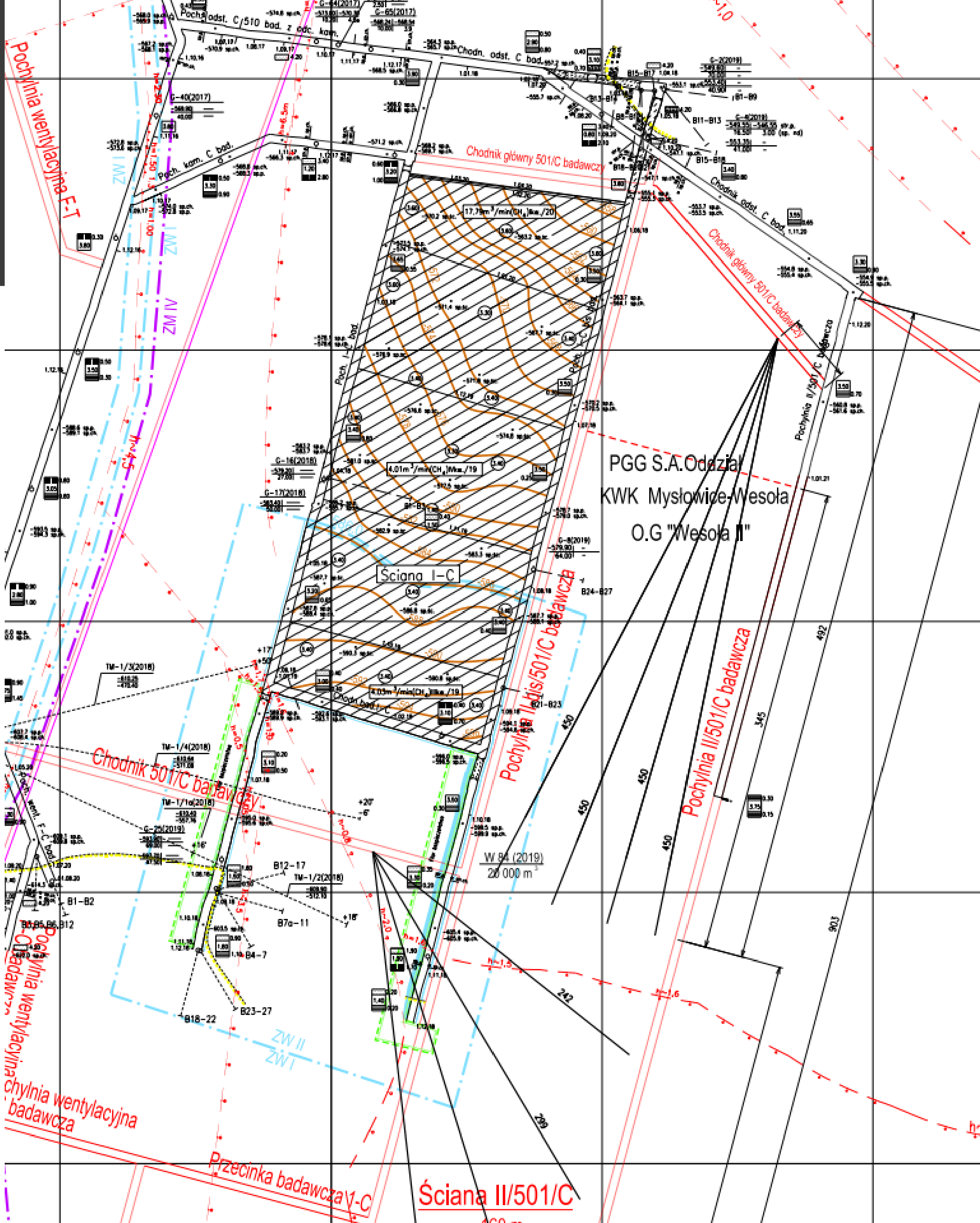


3D porosity model in the drainage area

CONCLUSIONS

AND FUTURE PLANS

- The preliminary results of pilot wells proved that LRDD technology is an effective tool for improving safety and productivity during coal extraction and helps reducing GHG emissions in SW CM
- The obtained high CH_4 drainage efficiency for LRDD wells could be a coincidence of high coal CH_4 content and good reservoir properties for barren rocks such as high permeability, moderate porosity, high uniaxial compressive strength – UCS
- Also, the location of LRDD wells with the favorable regime of the primary and secondary fracture system seems to play an important role in drainage efficiency
- This hypothesis is being verified using laboratory tests and geological modeling tools



THANK YOU FOR YOUR ATTENTION

DD-MET

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