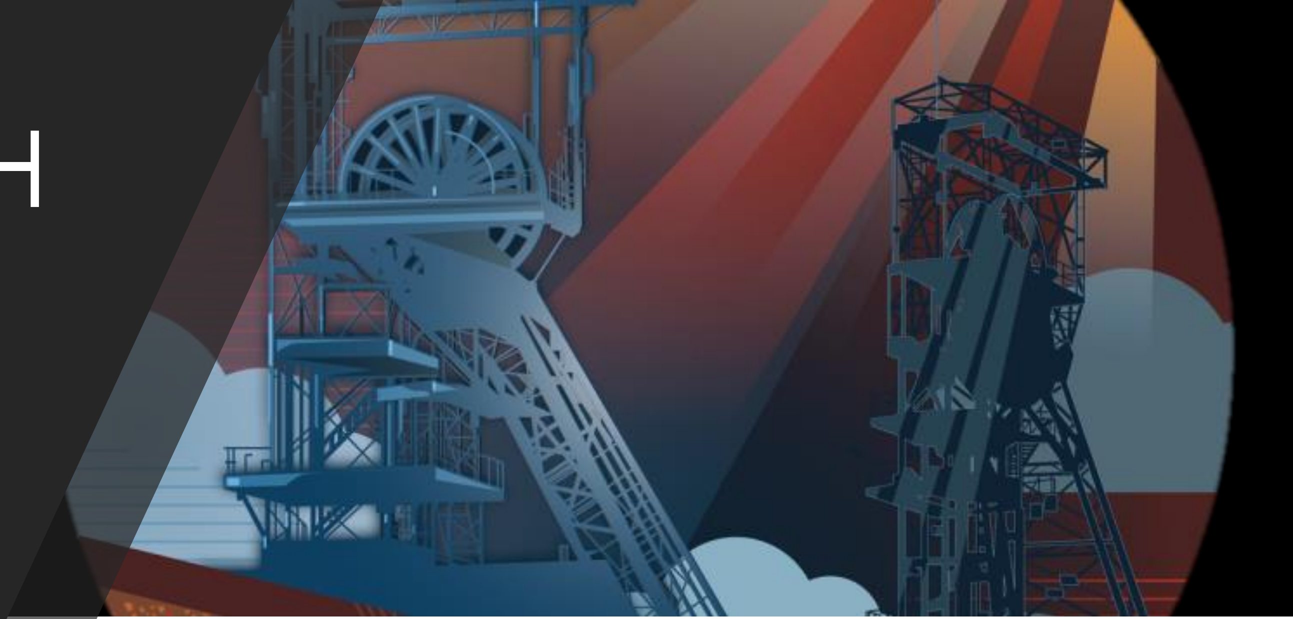
APPLICATION OF LONG-RICH DIRECTIONAL DRILLING

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



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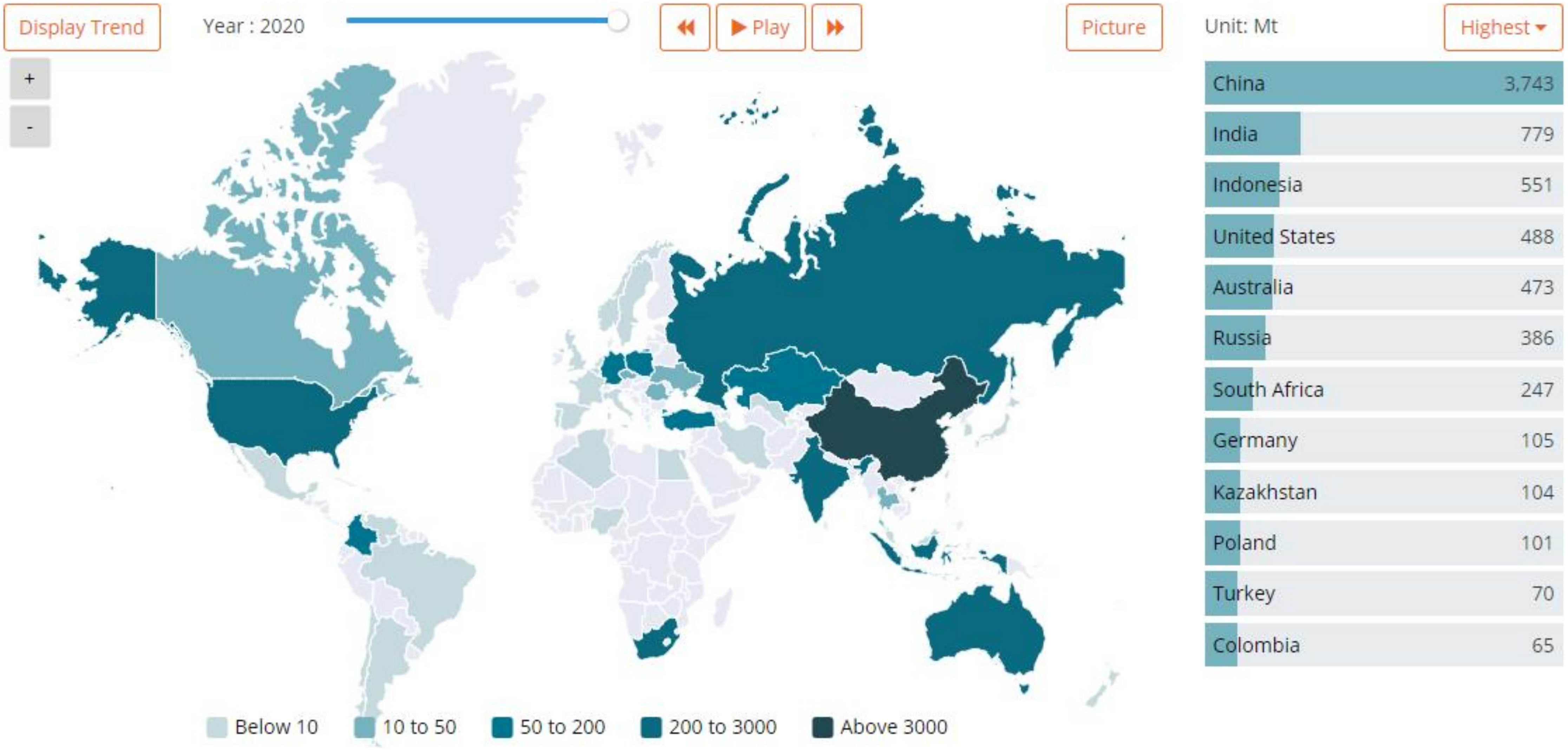
DD-MET

GIG · Universidad de Oviedo · Polska Grupa Górnicza · Imperial College London · ИПКОН

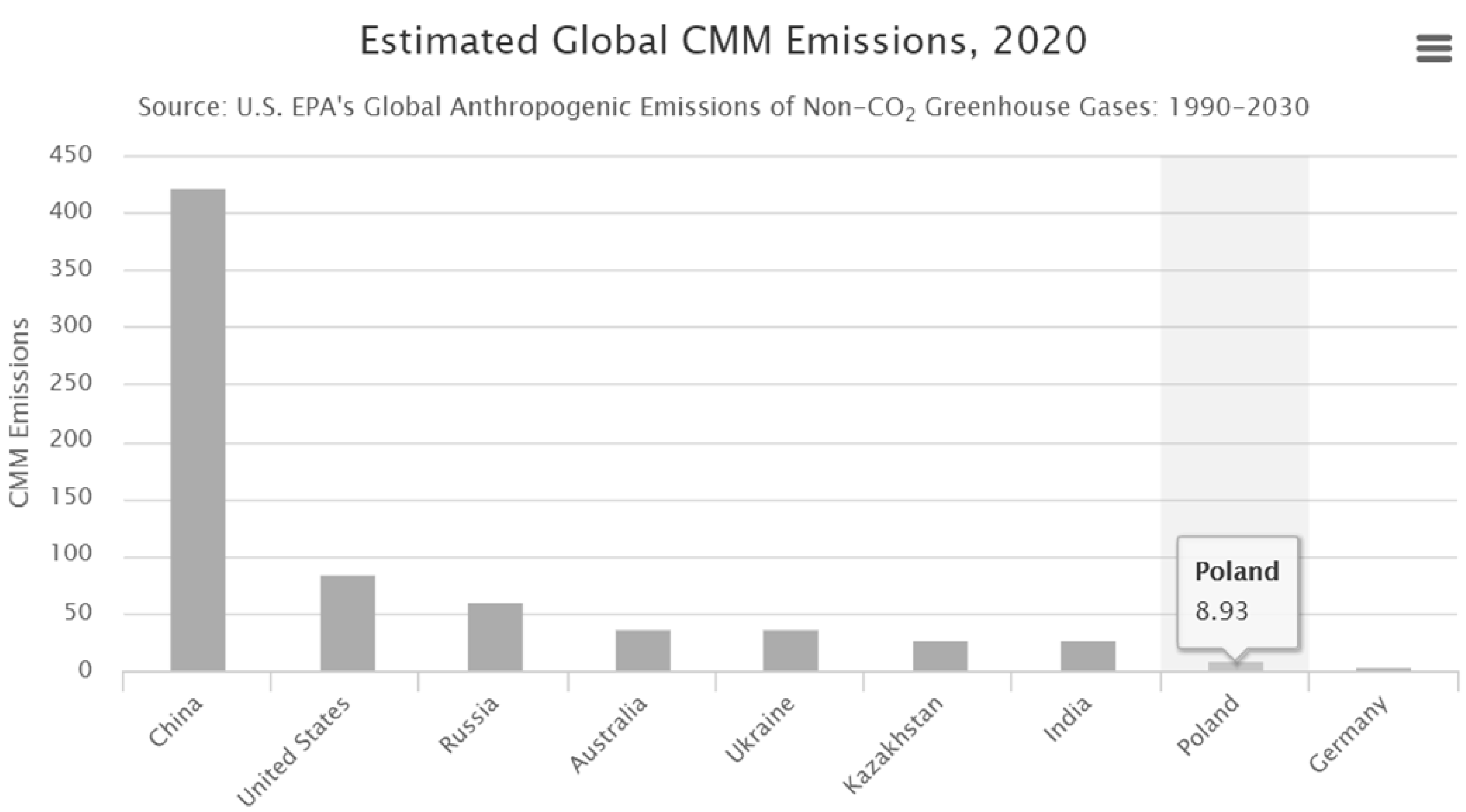
2021 International Pittsburgh Coal Conference

COAL PRODUCTION *IN SELECTED COUNTRIES*



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

GLOBAL CMM EMISSIONS

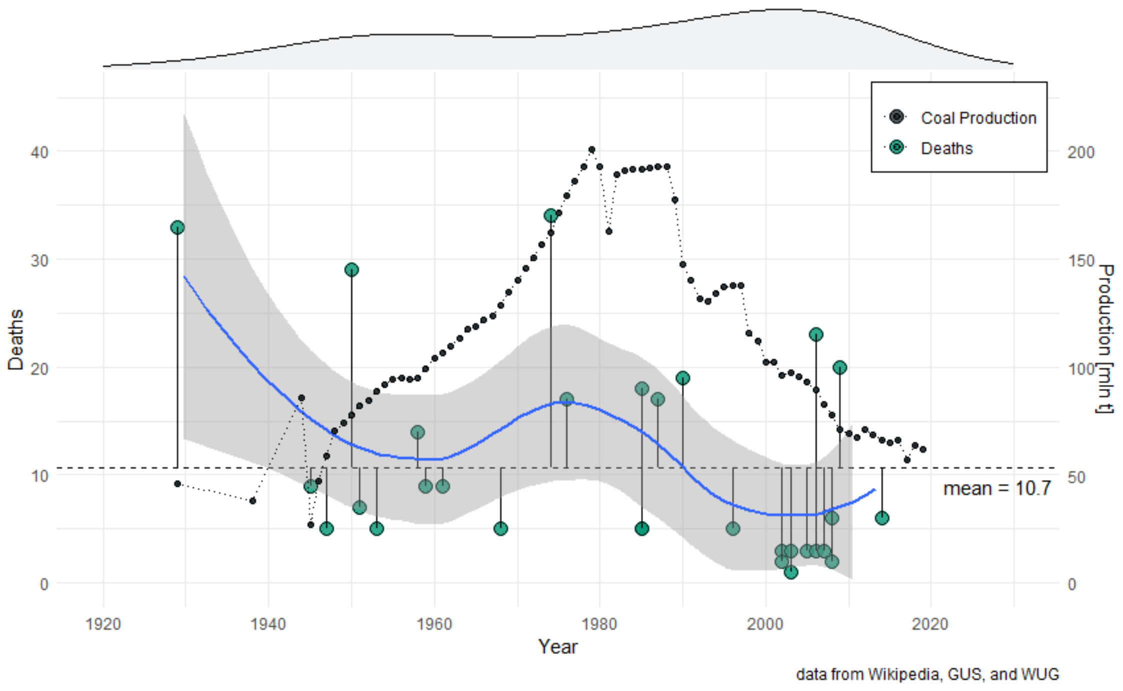


Source: https://www.epa.gov/cmop/frequent-questions

MOTIVATION

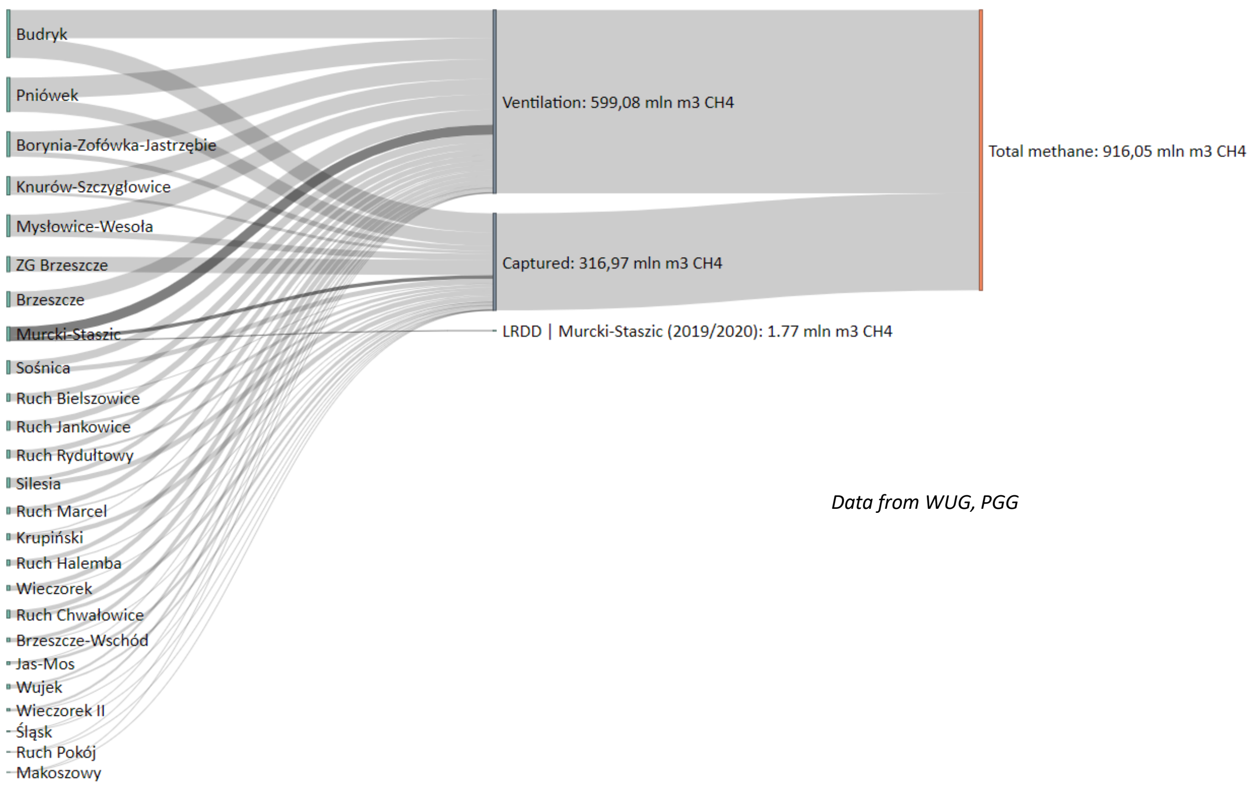
Reduce GHG emissions

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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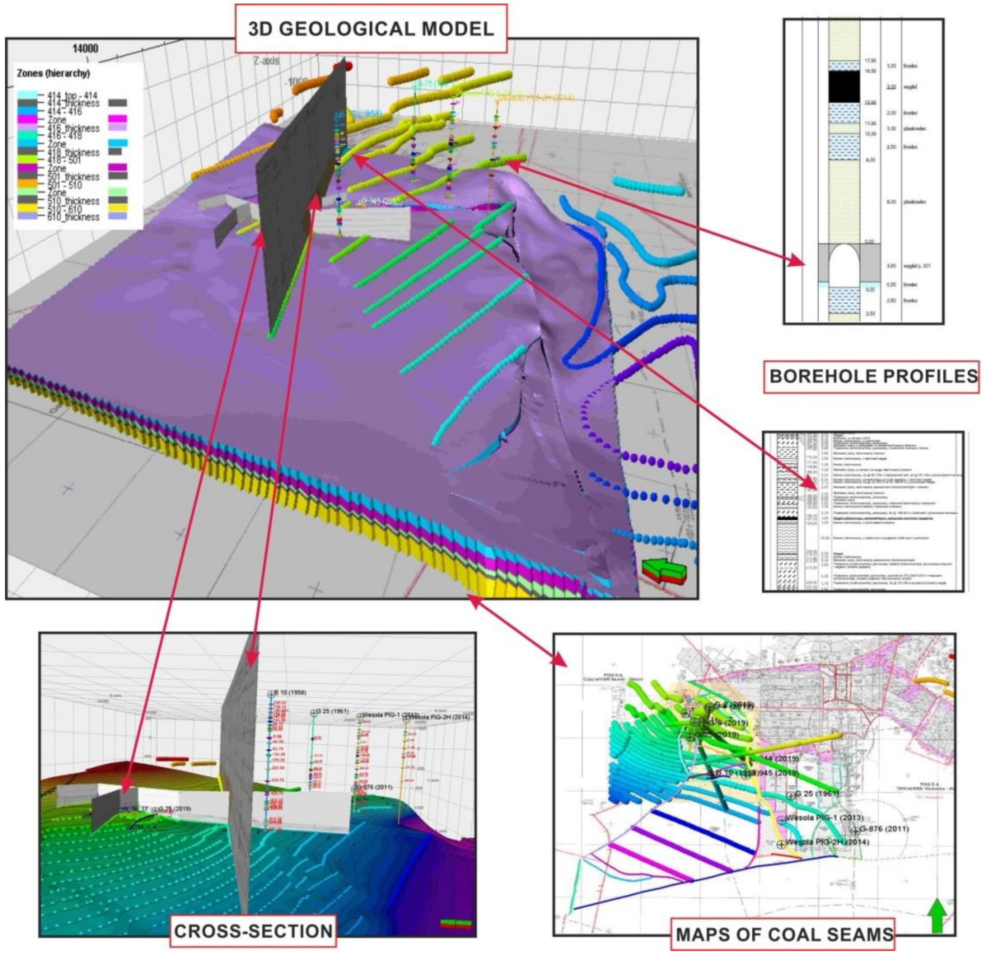


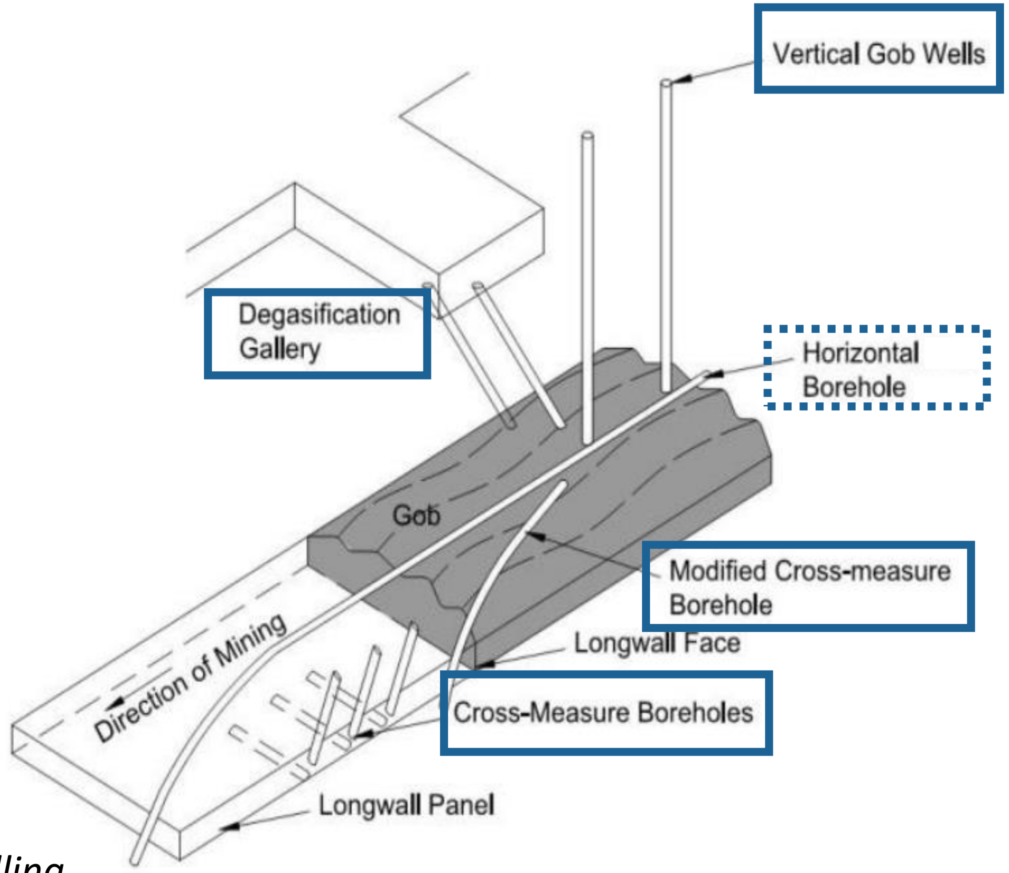
METHANE CONTROL STRATEGIES

- 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

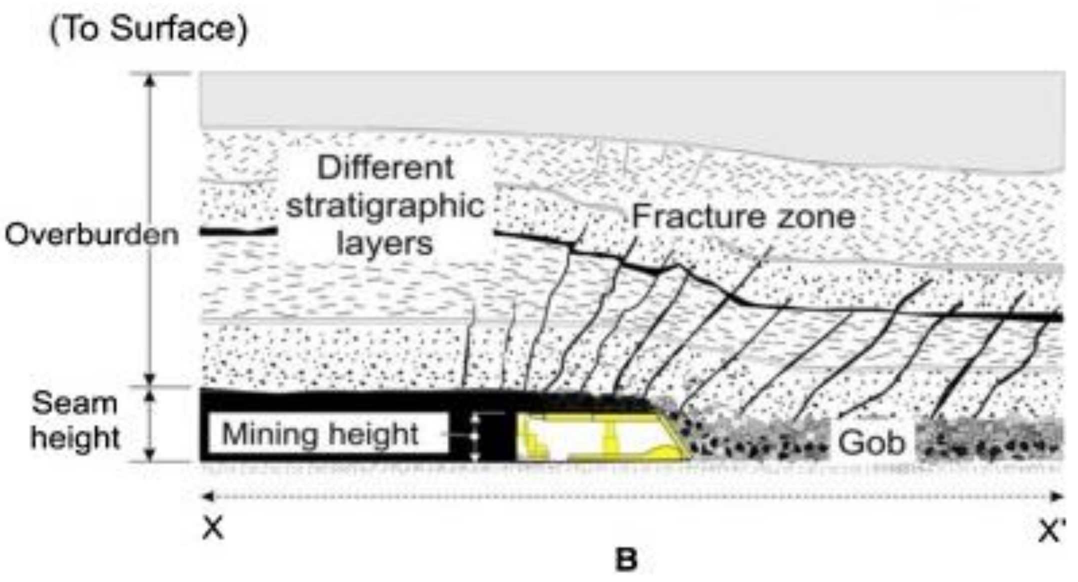
LONG REACH DIRECTIONAL DRILLING

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

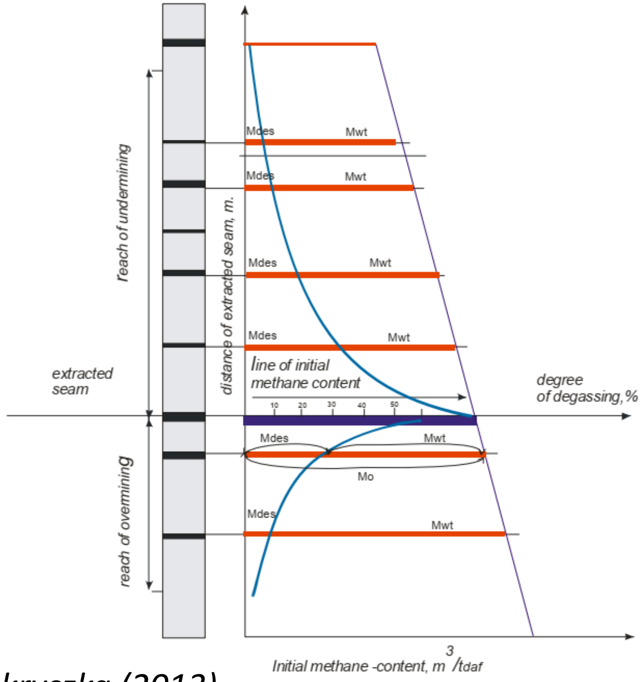
Drilled above the coal panel into the fractured zone (inside coal or sandstone) but above strata relaxation zone and gob zone

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

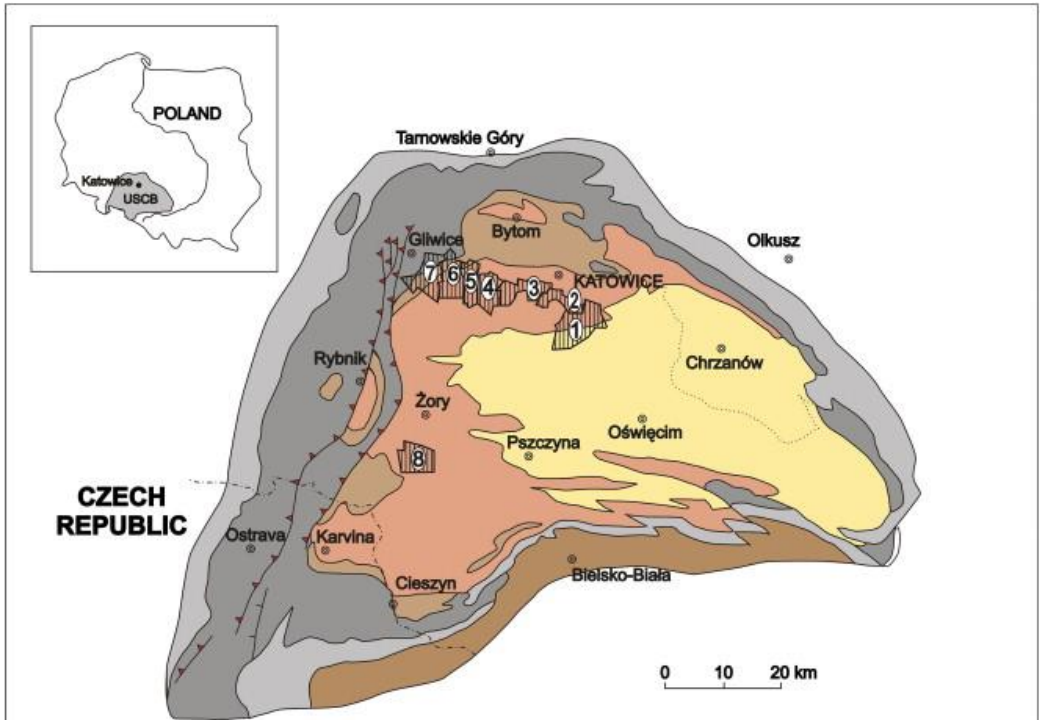


Karacan (2008)



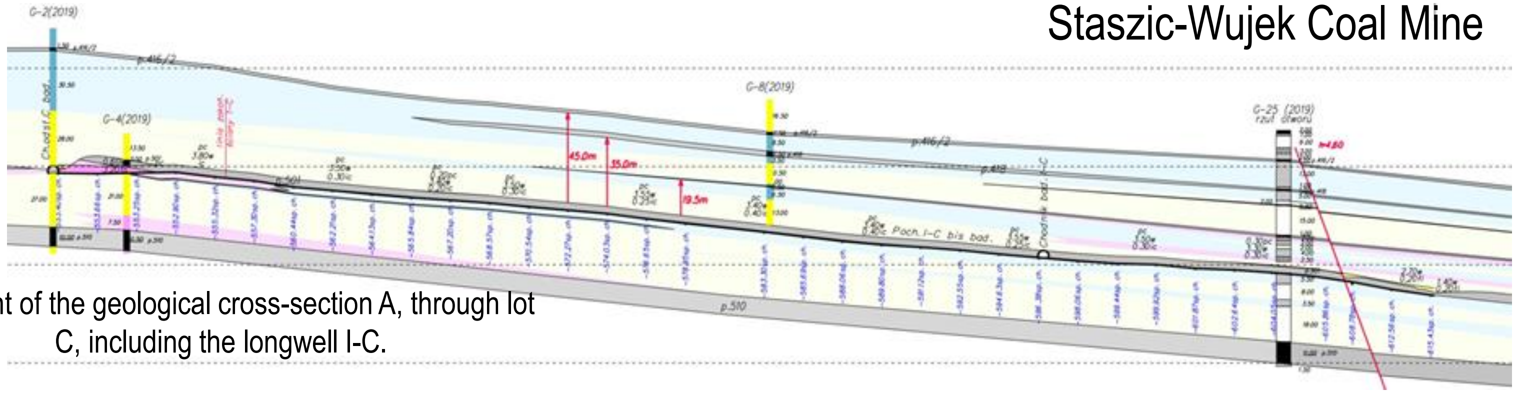
Krause and Pokryszka (2013)

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.

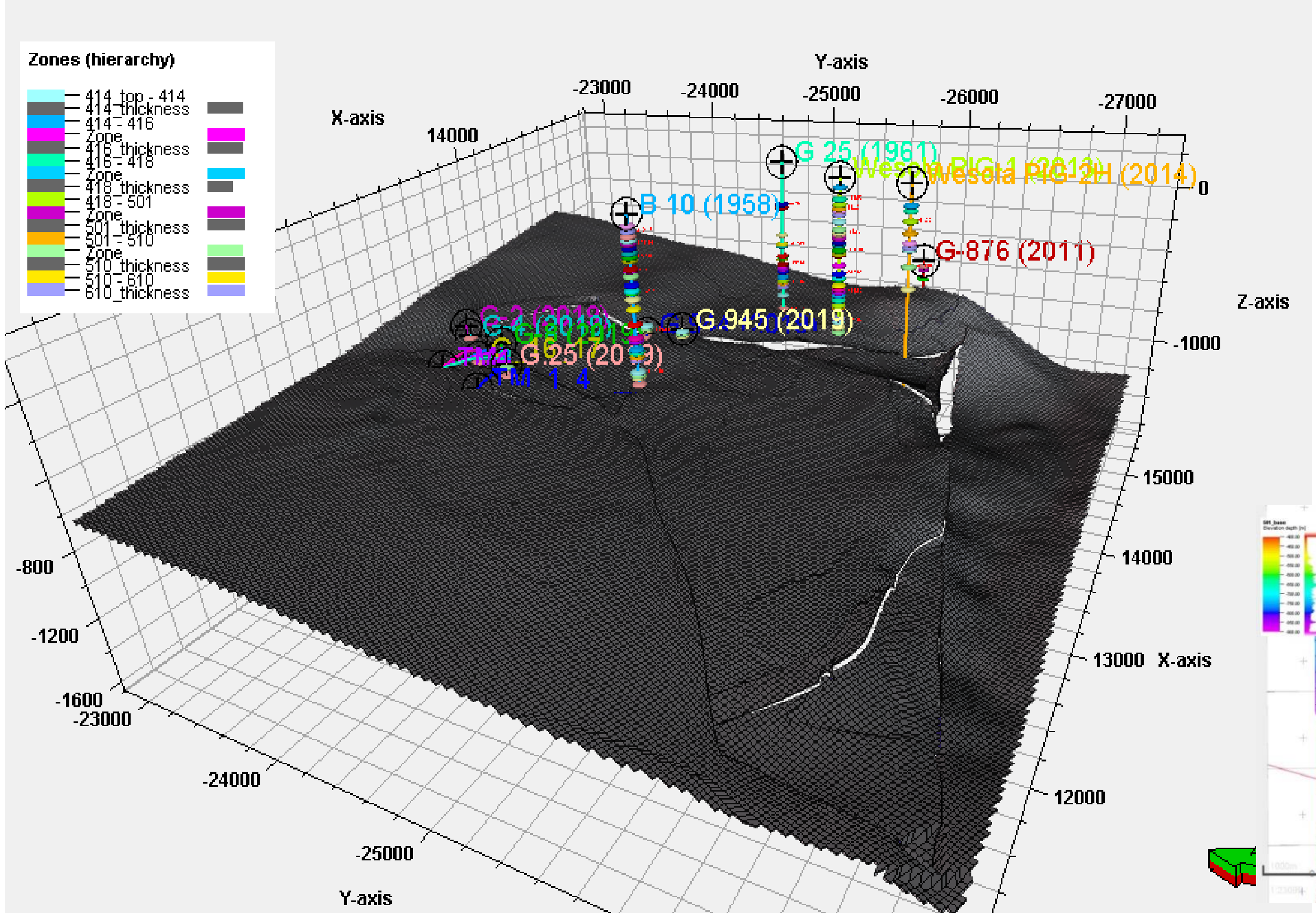
The **predicted absolute methane capacity** of the I-C coal panel is **high**,

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**

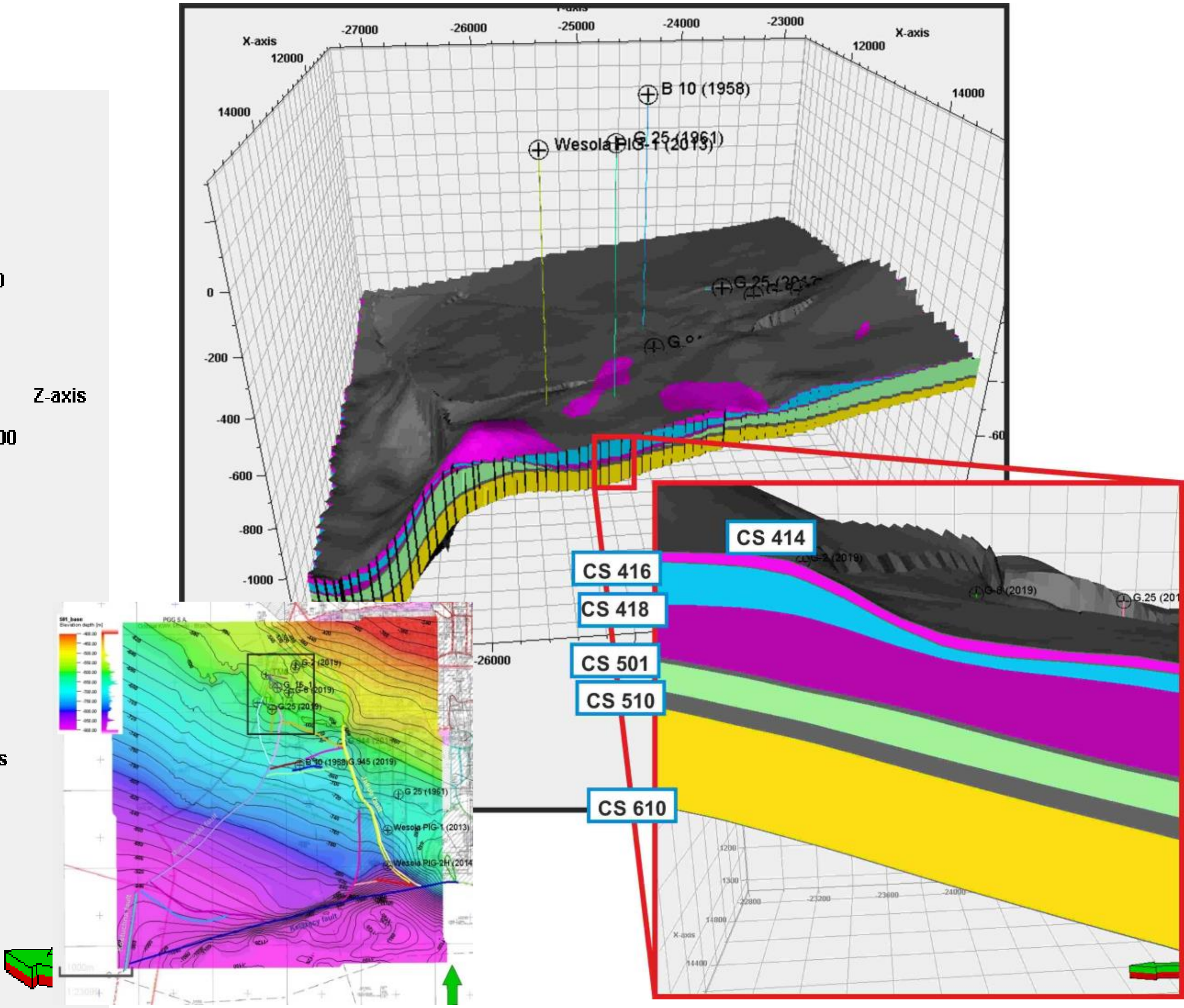
Mine experience acquired during the operation of coal panels in the **IV category of methane hazard**

AREA OF INVESTIGATION

Structure of 501 CS



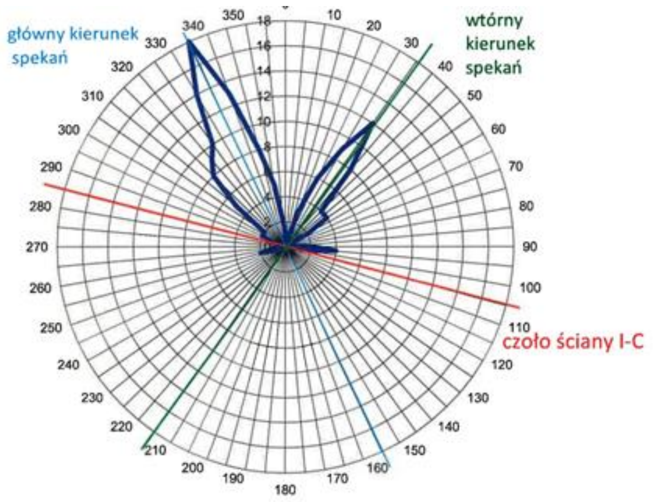
Horizontal resolution 25 x 25 m

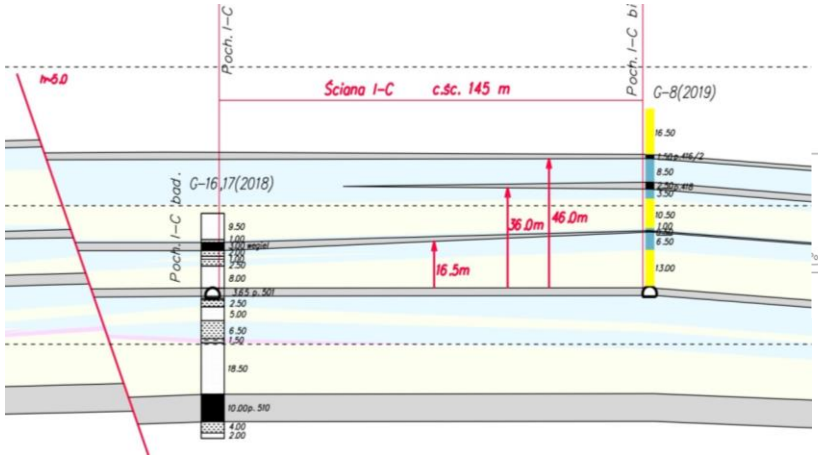


Structural model of the strata between 610 and 414 coal seams

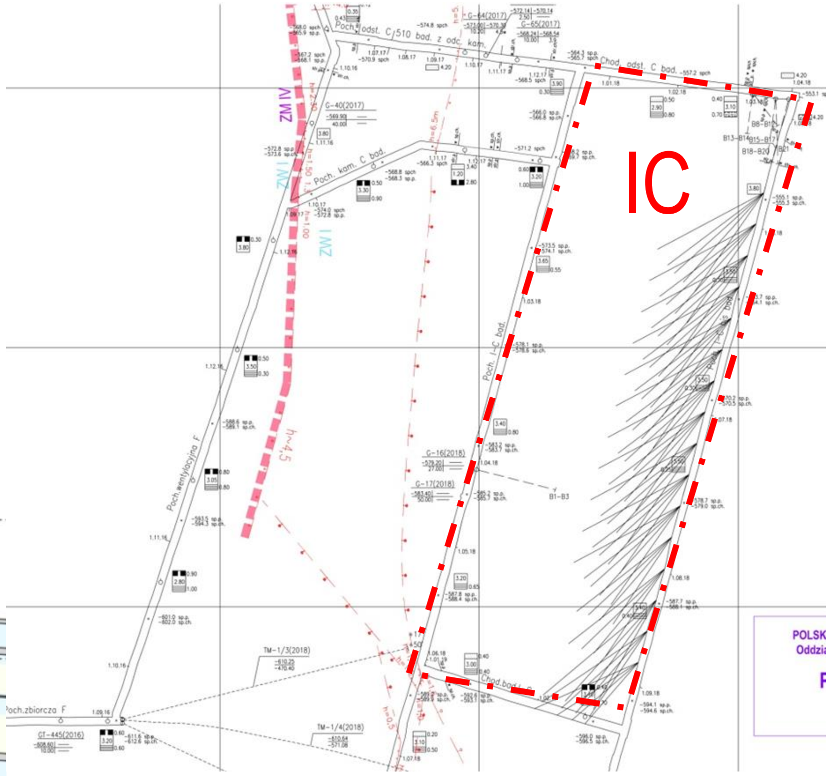
LOCATION AND TRAJECTORIES OF METHANE DRAINAGE BOREHOLES

"Fractures' rose" diagram

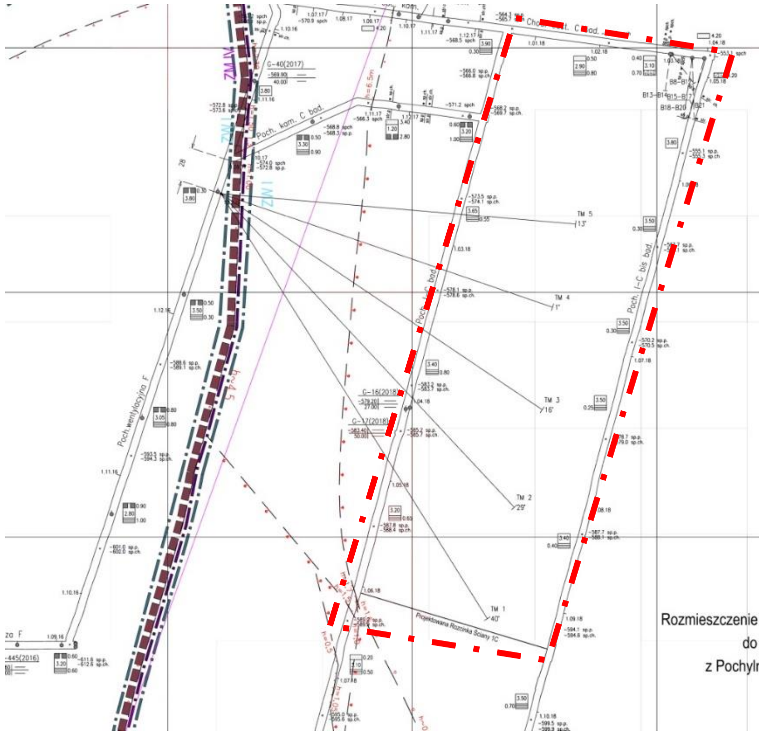




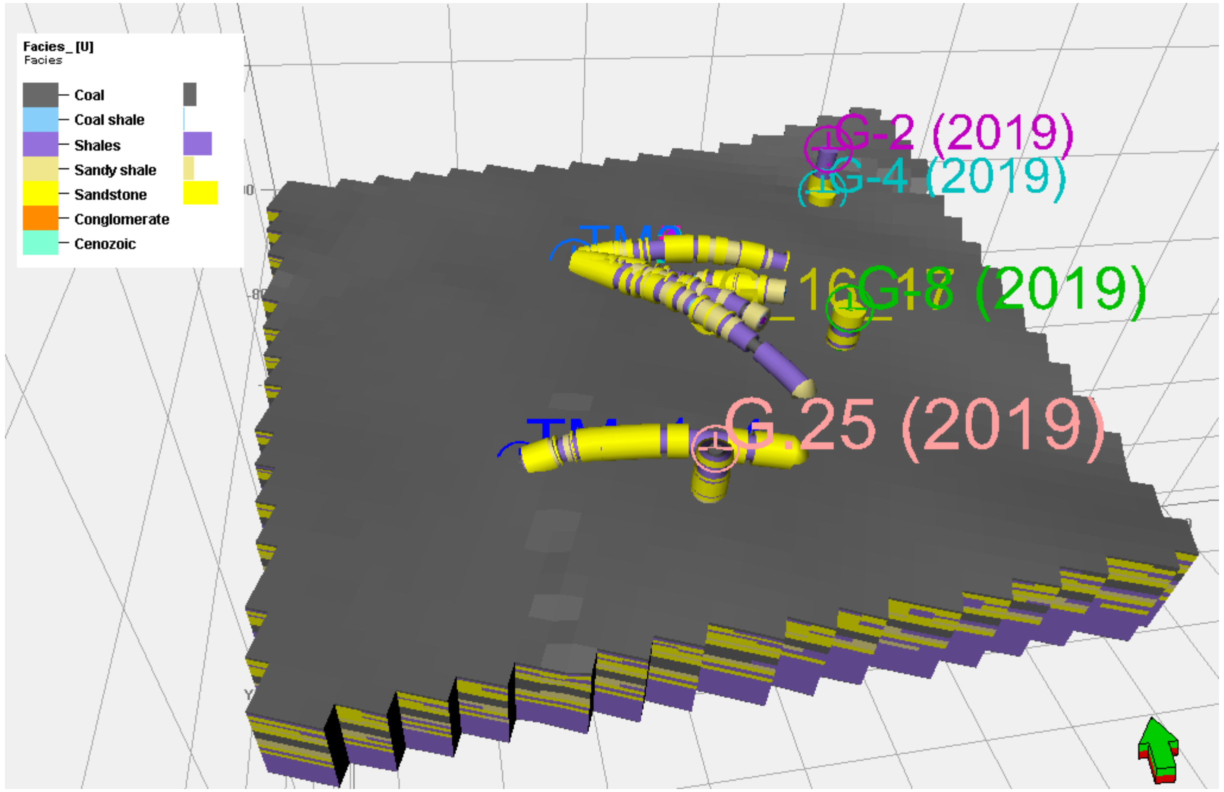
CONVENTIONAL

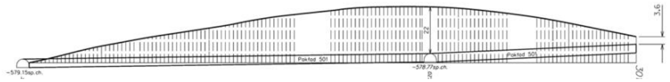


LRDD

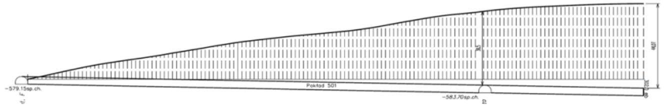


LOCATION OF LRDD WELLS



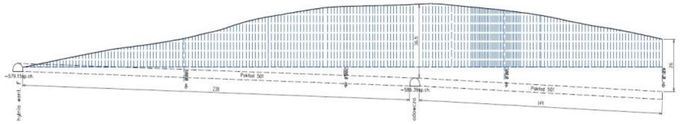


Bore hole nº TM 5. length: 302 m

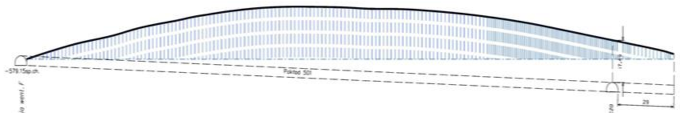


Bore hole nº TM 4. length: 301 m

Bore hole nº TM 3. length: 300 m



Bore hole nº TM 2. length: 401 m

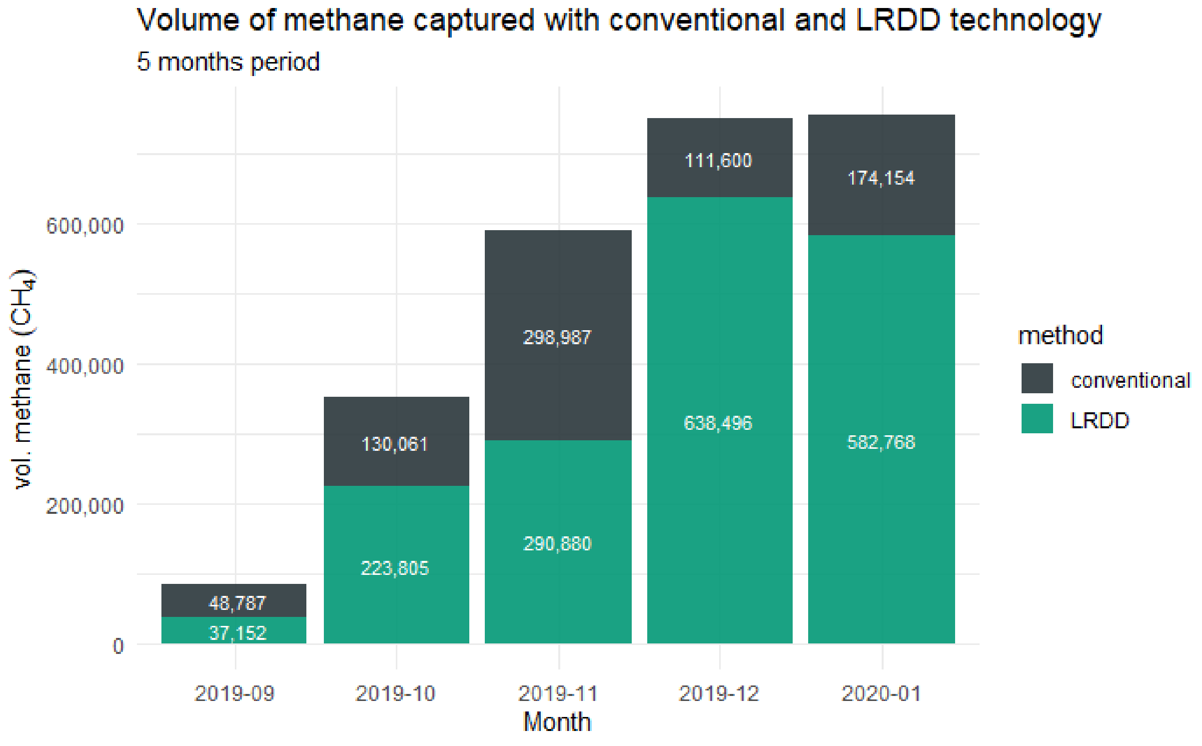


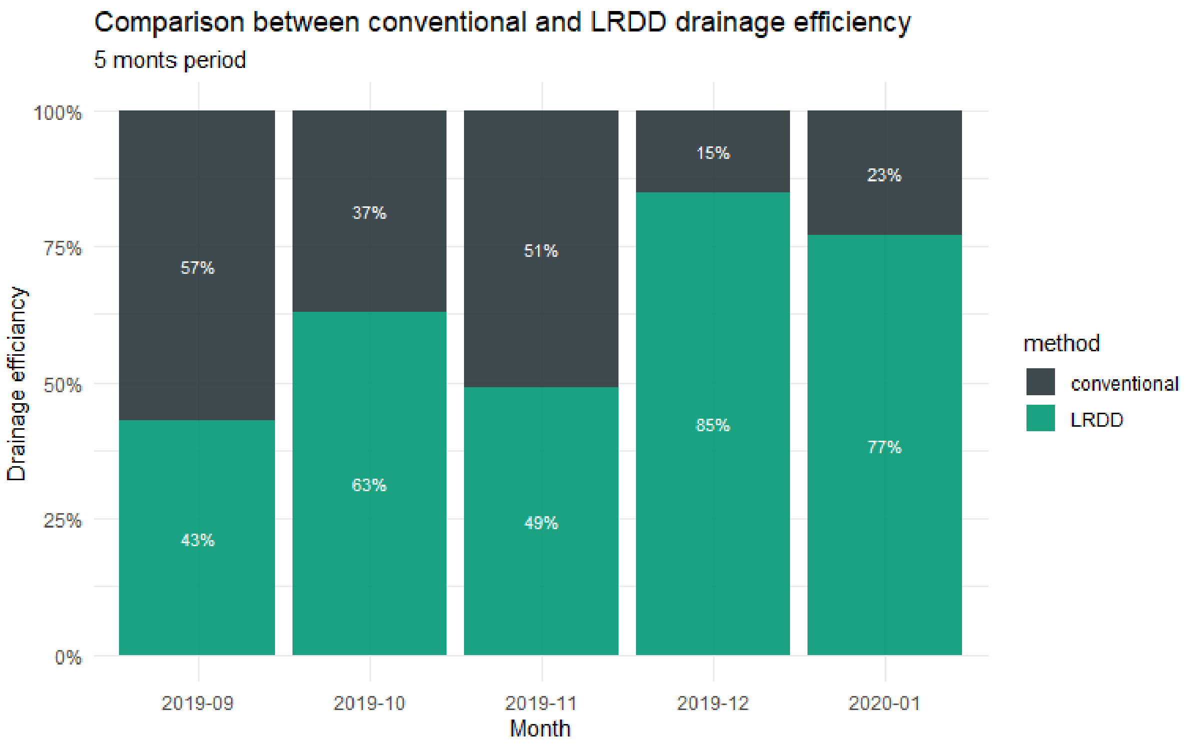
Bore hole nº TM 1a. length: 402 m

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

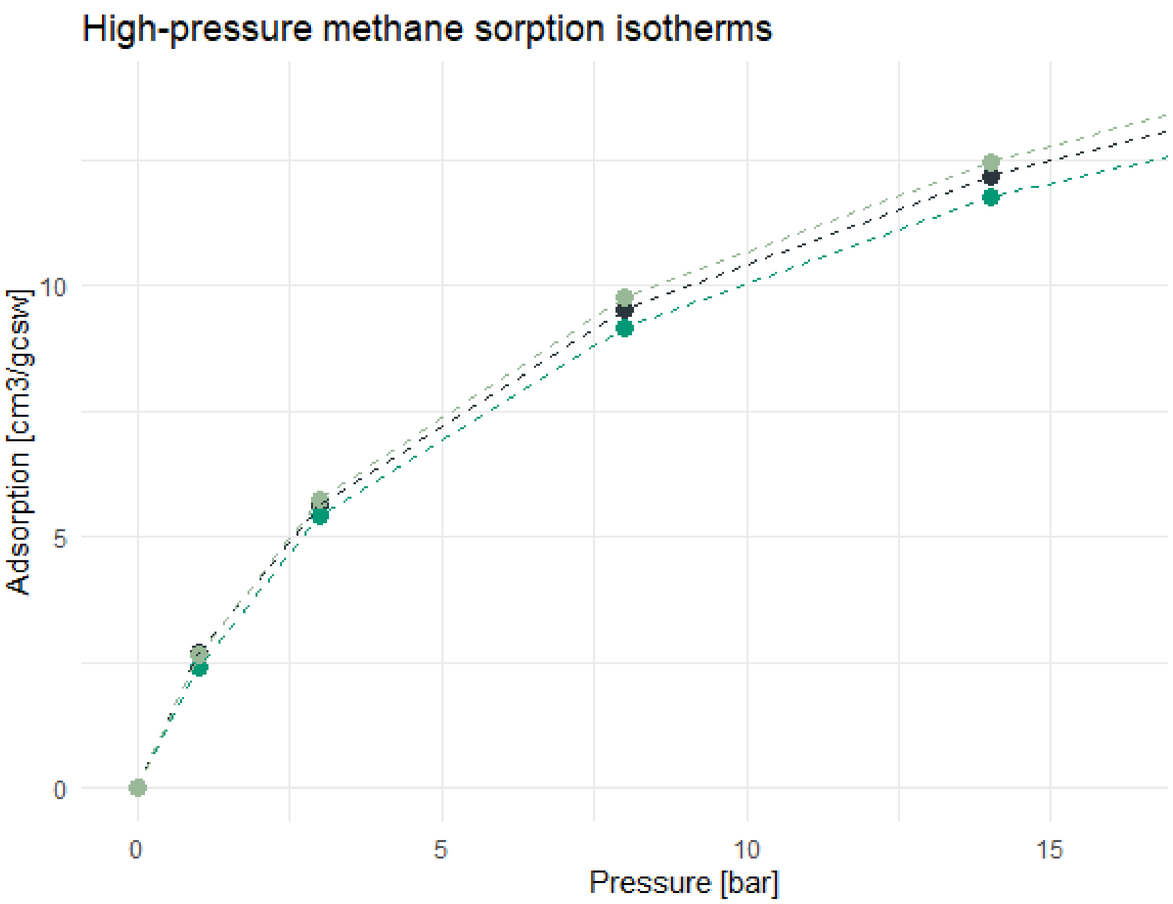
Conventional: 763 588.8 m^3 CH_4 (30.1%)
LRDD: 1 773 100.8 m^3 CH_4 (69.9%)
SUM: 2 536 689.6 m^3 CH_4





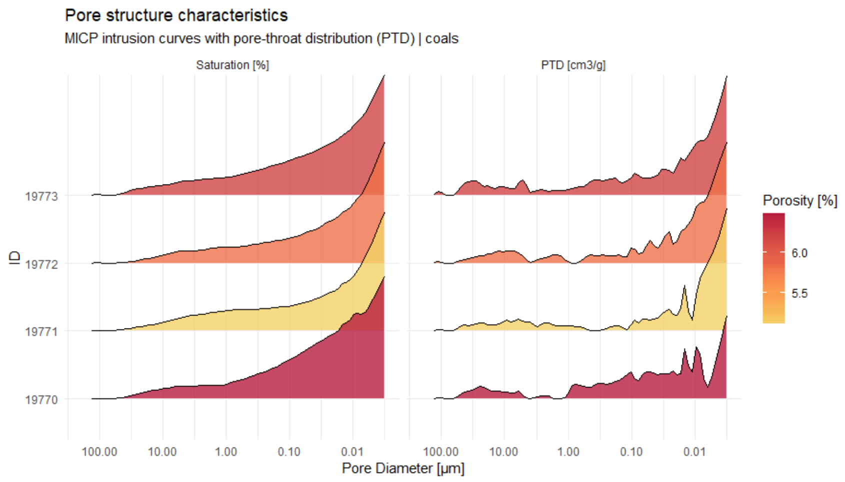
COAL PROPERTIES

SORPTION ISOTHERMS (selected samples)

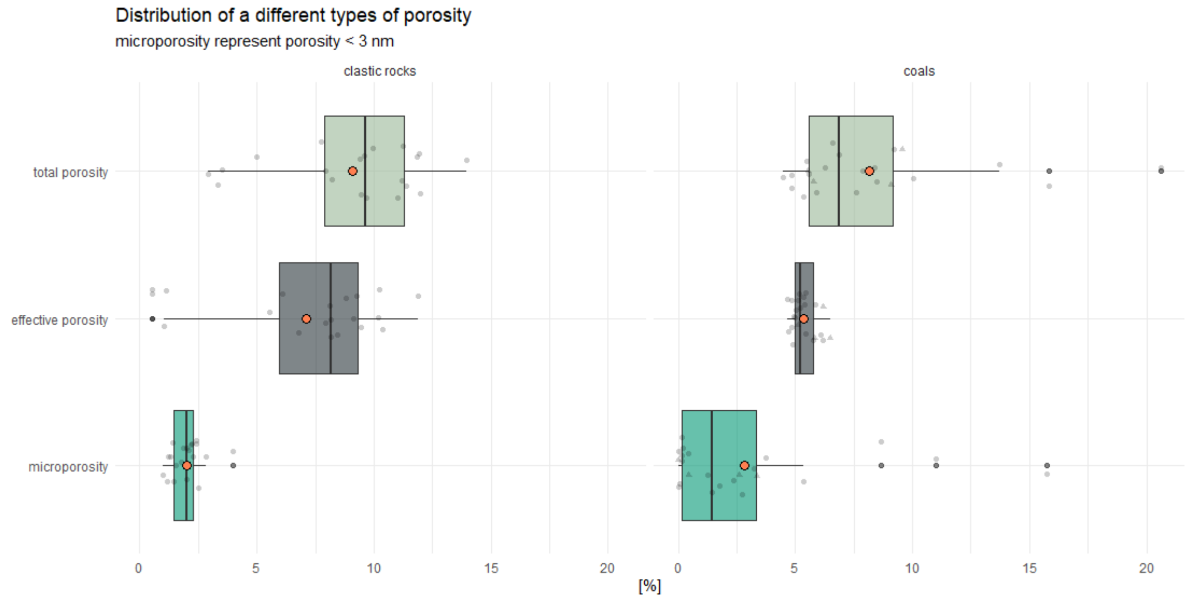


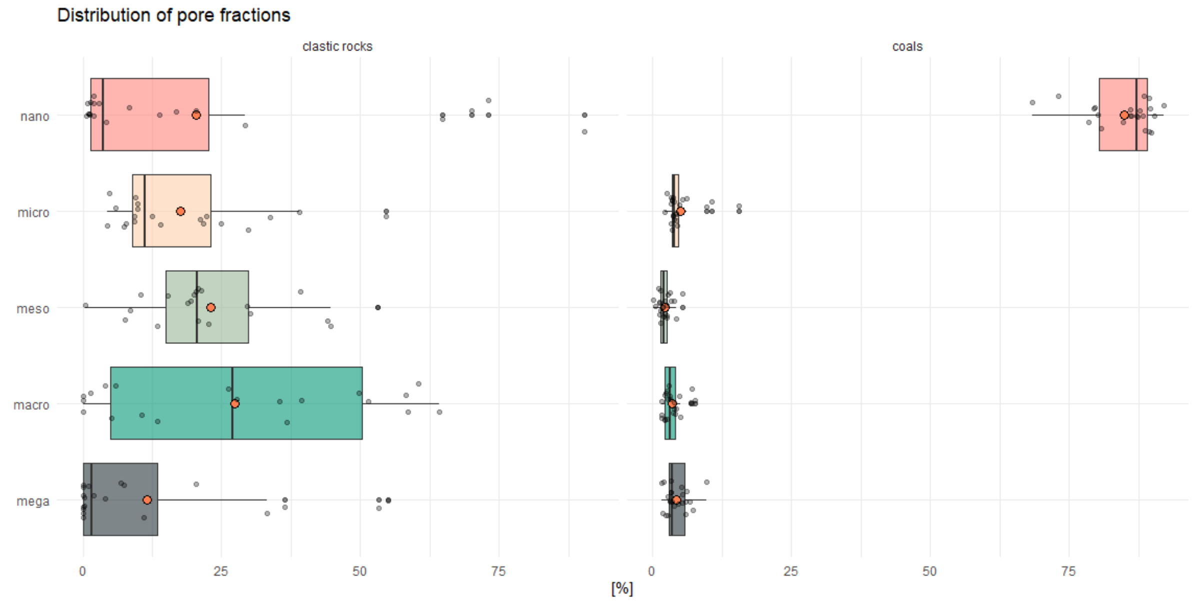
- Methane-bearing capacity test
- Chromatographic analysis
- Physico-chemical parameters
- (hygroscopic moisture content - Wh, ash content - A, volatile matter content – Vdaf)
- Sorption isotherms
- (sorption capacity, sorption capacity in reference to daf, effective diffusion coefficient, and half-time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

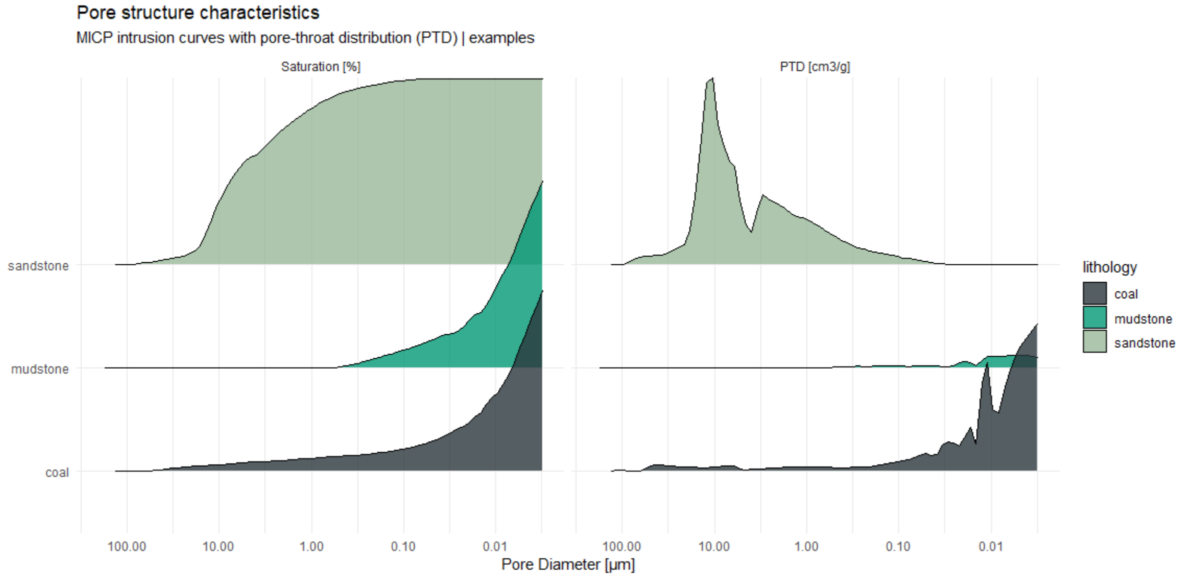
The sorption isotherms for the indicated pressures are similar, which is also reflected in similar pore structure of the analyzed coal samples



COAL PROPERTIES *PORE STRUCTURE*



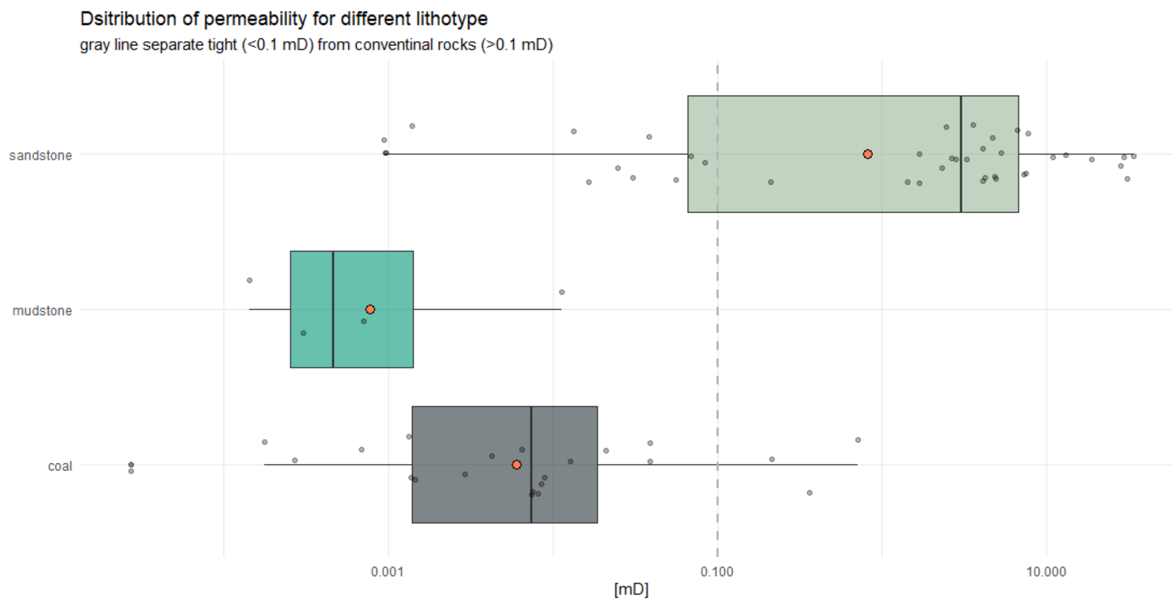


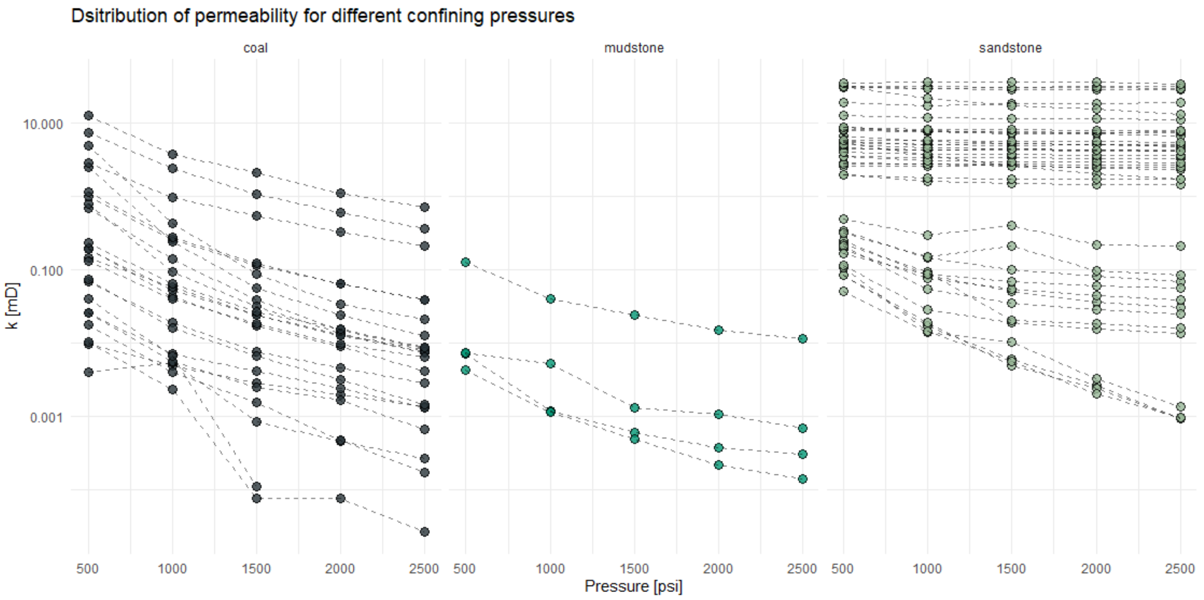


The total porosity for clastic rock is moderate with median at about 10%. For coal samples the median of total porosity is about 6%.

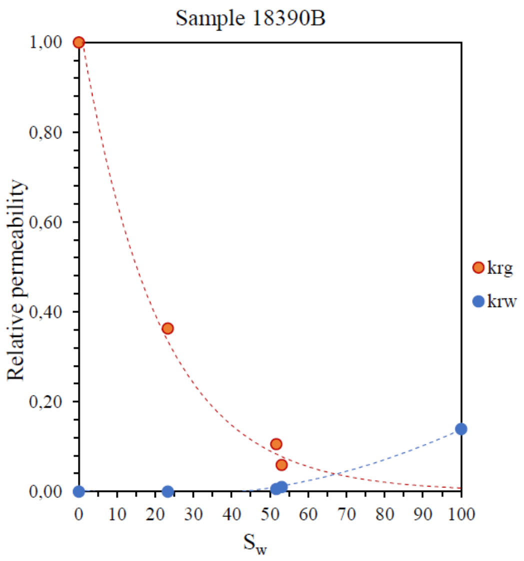
Clastic rocks are dominatd by macropores (2-10 um) while coals are almost completedy dominated by nanopores (<0.1um)

COAL PROPERTIES *FILTRATION PROPERTIES*





2 rock-types of sandstone samples



k_{abs} = 10.22 mD

$\phi_{effective}$ = 9.25 %

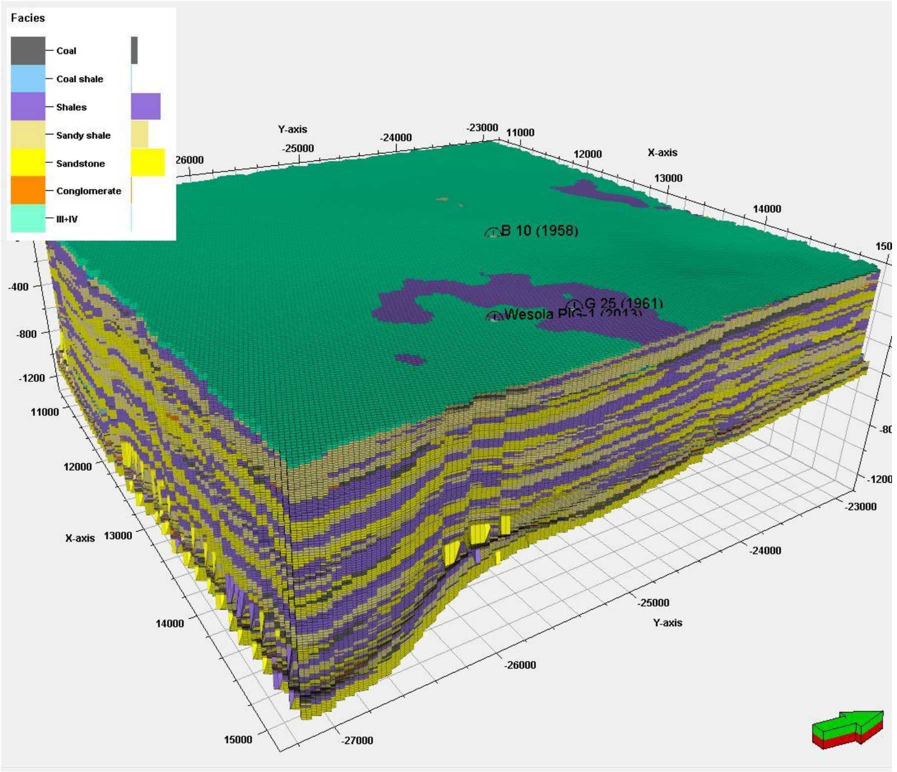
ϕ_{total} = 11.24 %

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

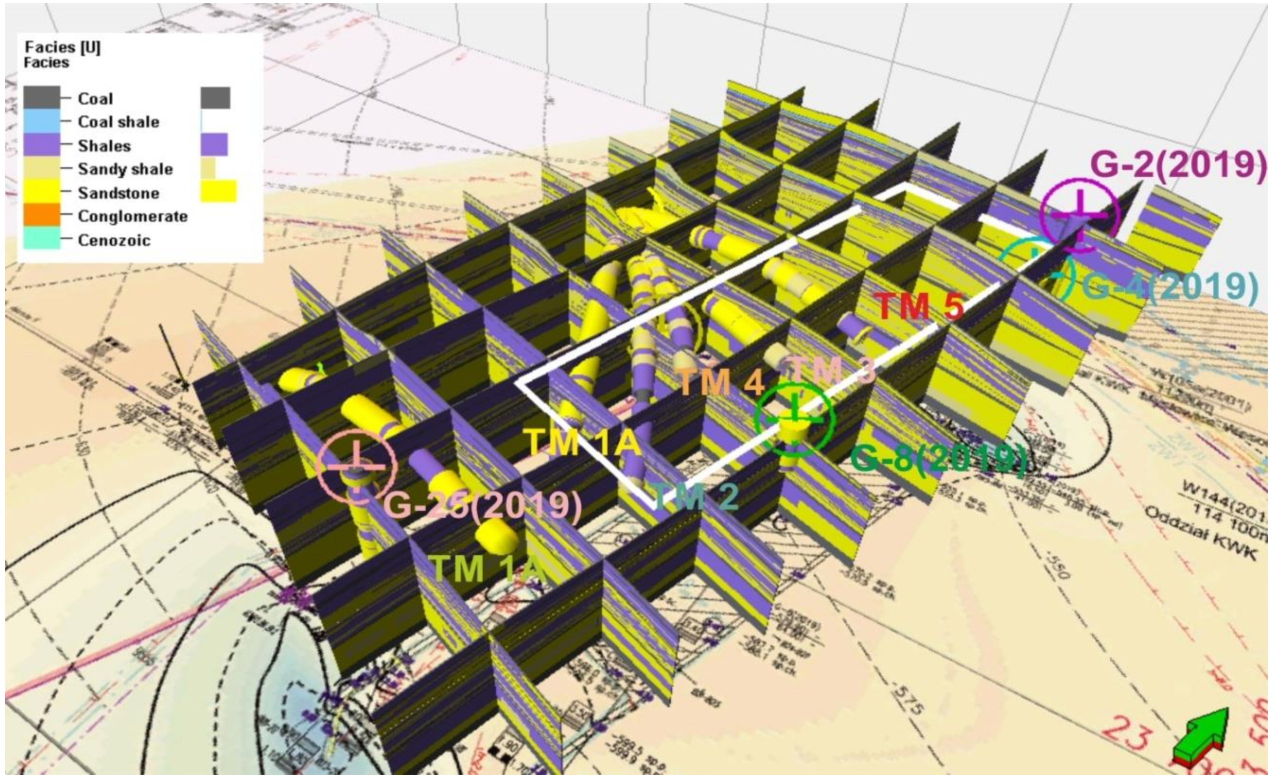
GEOLOGICAL MODELLING *LITOTHYPES*

Geostatistical analysis



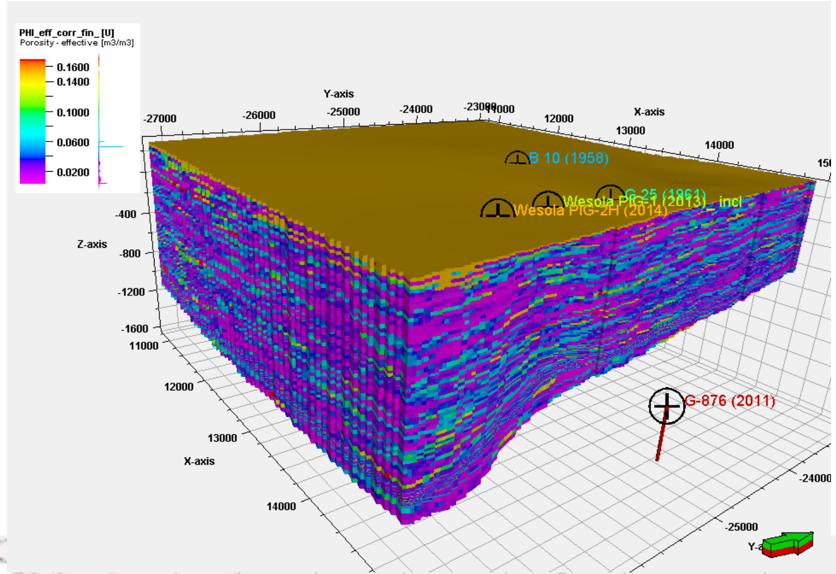
Horizontal resolution 25 x 25 m

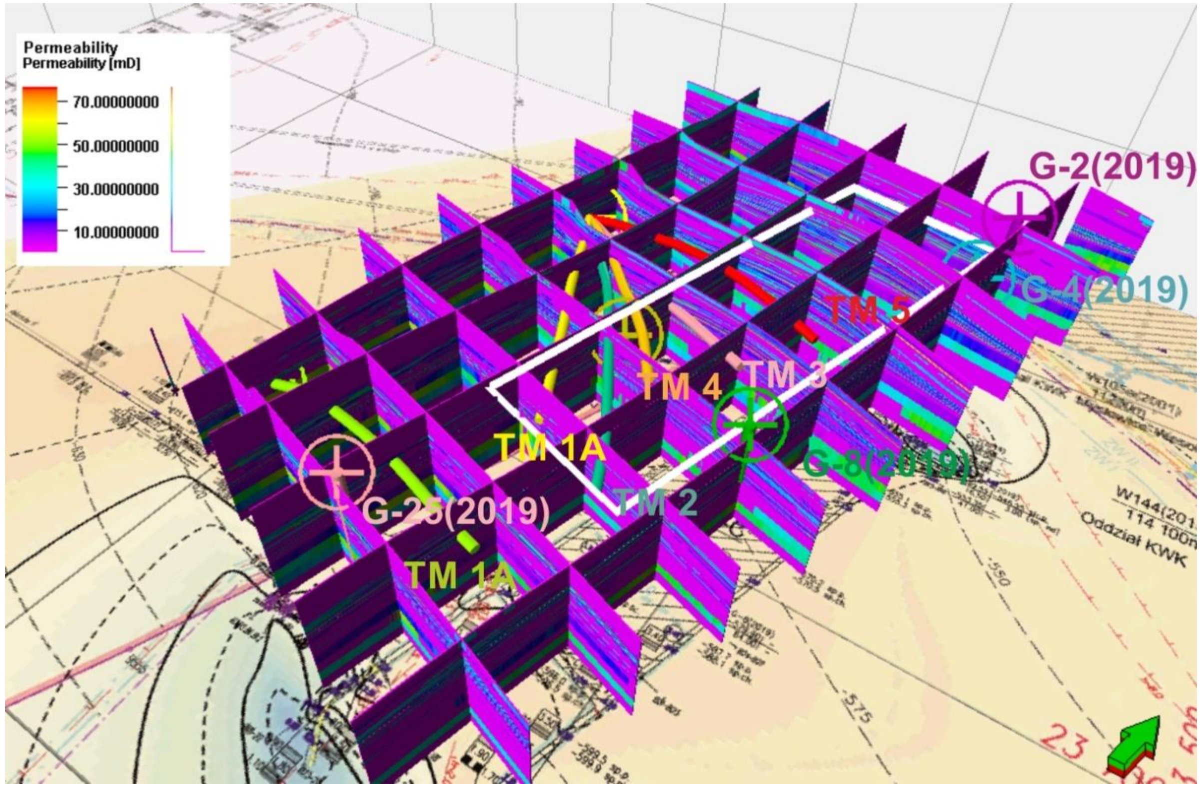
3D model of lithotypes occuring in the drainage area



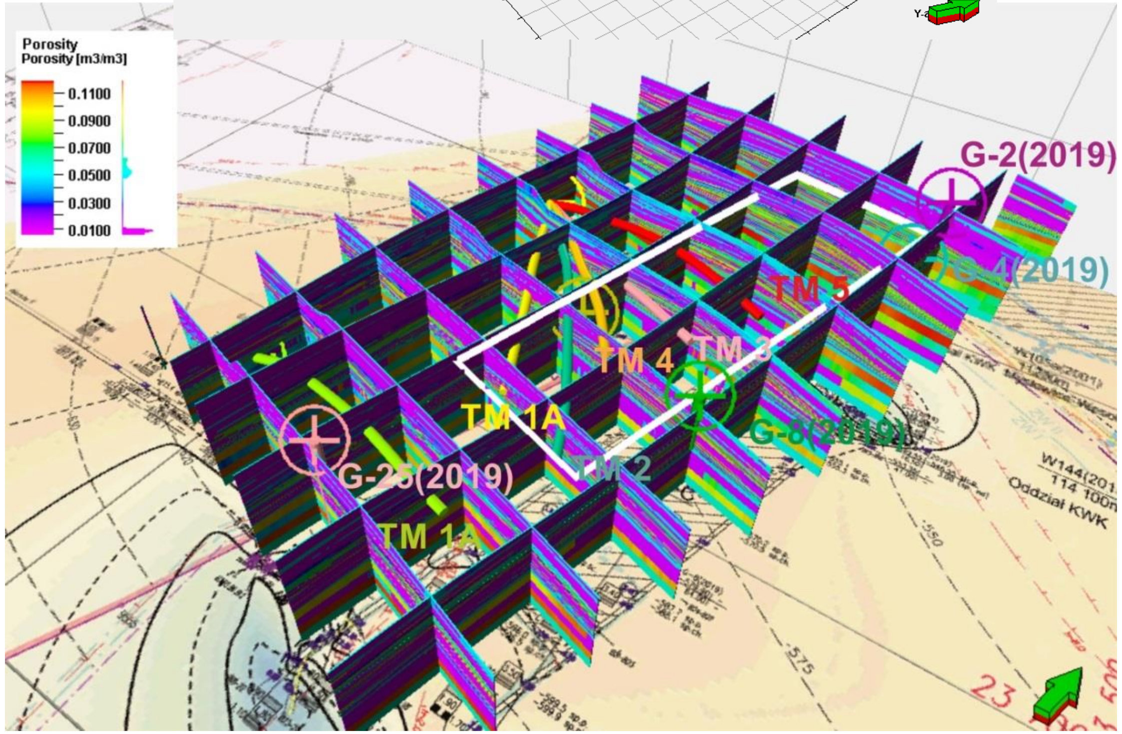
Horizontal resolution 1 x 1 m

GEOLOGICAL MODELLING *PHI/K*





3D permeability model in the drainage area

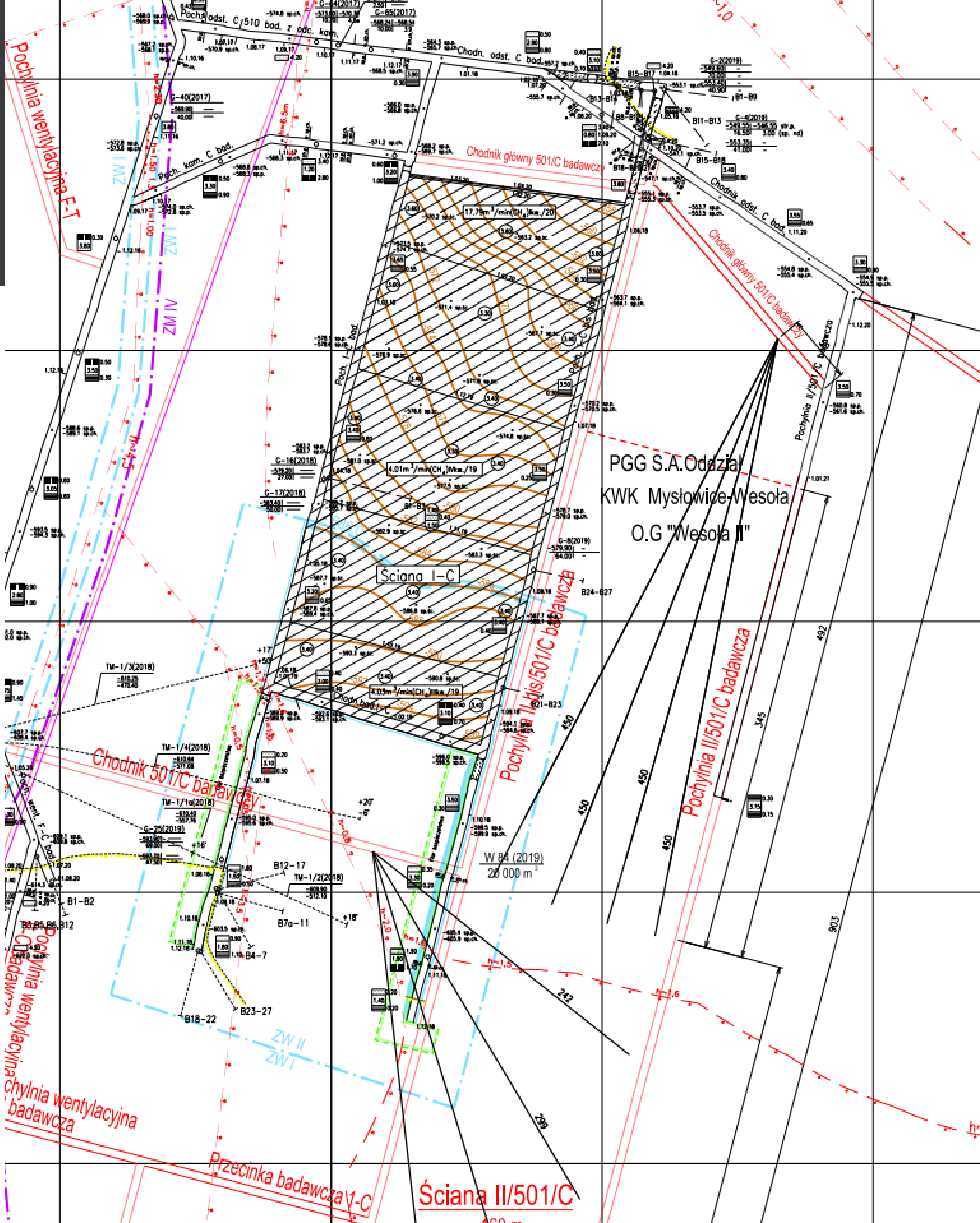


3D porosity model in the drainage area

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

The presented work received funding from the European Commission Research Programme of the Research Fund for Coal and Steel Technical Group Coal 1 TGK1 Grant Agreement number: 847338 — DD-MET RFCS-2018/RFCS-2018