Pre-Mine Drainage in Poland
GŁÓWNY INSTYTUT GÓRNICTWA
(GIG)
CENTRAL MINING INSTITUTE
is a scientific-development organization combined since the year 1945 with the Upper Silesian extractive industry and region
Where are we?

We are in the heart of Polish hard coal mining industry - in Upper Silesia, in Katowice

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AREAS OF GIG’s activities

Environmental engineering

Mining and Geoengineering

Quality

Education
Coal in Europe and Poland

Poland in 2017 [mln Mg]

Source: Euracoal
The role of coal in power generation in Poland

**POLAND**

**EU 28**

Coal’s share 23 %

Coal’s share 32.10%

Source: EURACOAL
Location of major Polish coal basins

- Resources: 56,220.48 Mt
- Economic resources: 3,573.69Mt
- Production – 65.5 Mt,
  - 82% Mt Steam coal,
  - 18% Mt Coking coal
- Number of hard coal mines – 30
- Hard coal companies:
  - Polska Grupa Górnicza
  - Jastrzębska Spółka Węglowa
  - Węglokoks Kraj Sp. z o.o.
  - Spółka Restrukturyzacji Kopalń S.A.
  - Tauron Wydobycie S.A.
  - Lubelski Węgiel Bogdanka
  - Others mines (Siltech, Eco-Plus, Silesia)
- Employment – about 85,000 workers
The coal seams are mined in conditions of natural hazards

- Gas hazards
- Fire hazard
- Dust hazard
- Seismic and rock burst hazard
- Water hazard
- Climatic hazard
- Radiation hazard

Such mining conditions negatively affect the costs of mining activity of Polish companies
Absolute methane bearing capacity, methane drainage, amount of economically utilized methane coal production output in Polish hard coal mines in the years 2007-2017

<table>
<thead>
<tr>
<th>Specification</th>
<th>Year</th>
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<tbody>
<tr>
<td>Absolute methane bearing capacity (mln m³/year)</td>
<td>878.9</td>
</tr>
<tr>
<td>Methane drainage (mln m³/year)</td>
<td>268.8</td>
</tr>
<tr>
<td>Amount of economically utilized methane (mln m³/year)</td>
<td>165.7</td>
</tr>
<tr>
<td>Number of the hard coal mines</td>
<td>31</td>
</tr>
<tr>
<td>Hard coal output (mln tones)</td>
<td>87.4</td>
</tr>
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</table>
Methane in Polish coal mines

- In 22 mines hard coal was extracted from methane seams – release of methane;
- In 3 mines hard coal was extracted from methane seams – without release of methane;
- Only 6 mines carried out coal extraction in no-methane seams;
- In 17 mines the drainage of the coal seams were carried out – by 20 surface and 7 underground methane removal plants
Methane in Polish coal mines

- Methane accompanying the hard coal exploitation is extremely dangerous for the underground work environment and it is also one of the most active greenhouse gases.
- Methane drainage in underground excavations in Polish mines is conducted to ensure the safety of mining operations.
- Most of the drained methane is released to the atmosphere.
Total gas released during mining operations

(about 948.5 mln m³)

- Ventilation Air Methane (VAM) 64%
- Drainage gas 36%
Methods of methane drainage:

Methods of rock strata methane drainage

- From the ground surface
  - Ahead of mining
    - Vertical wells
    - Directional boreholes
  - Exploitation-ones
    - Conventional drainage
    - Driange galleries
    - Underground directional drainage (new)

- Underground
  - Ahead of mining
Methods of methane drainage in Poland:

- drainage of the coal seams ahead of mining (before exploitation),
- drainage during coal exploitation,
- drainage of goaves.
Desorption zone is part of relaxation zone.
Diagram – cross section through the coal panel

Coal exploitation destroys structure of the overlying and underlying coal seams, releasing large volume of methane (20-40%) from the exploited seam, the remaining part comes from neighbour seams.

Diagram of the section along the coal panel

High of desorption zone depends from:
- Length of exploited panel,
- Incline of the coal panel,
Using conventional drainage

**Conventional drainage technology** – consists in drilling in the roof layers several boreholes (fan) with the length of 60-80m, every 20-35 m from drainage gallery into desorption zone BUT ABOVE RANGE OF DIRECT CAVING (full) : 4 - 6 x thickness of coal exploitation seam where the released gas is being cumulated during coal panel mining.

**Parametrs :**

Gas capture is starting about 60 m from the longwall coal face.

Max capture occurs in the 38-15 m distance from the coal panel and reaches 5-6 m³/min.
Drainage of the coal seams

Using drainage gallery

At the outlet of drainage gallery isolation plug is installed connecting gallery with drainage pipeline (depression)
Drainage of the coal seams

Using underground directional boreholes

Underground directional boreholes: are drilled above the coal panel – into the fractured zone, but above strata relaxation zone, above gob zone (inside the coal seam or sandstone).

The conceptual GOAL is to drill the boreholes below the lowest coal seam, which is the source of gas but high enough to keep them as long as possible open to enable gas drainage all over the borehole length during the longwall face progress.
Factors having impact on the increase of methane hazard in coal panels in Polish hard coal mines

Increase of exploitation depth (average by 8m/year)
- Increase of coal seams’ methane content
- Change of gas properties of the coal seams
  - Increased emission of methane into environment of the coal panels and developed roadways
  - Increase of gas and dynamic phenomena hazard in the coal seams prone to rock-bumps and methane outbursts

Coal output concentration
- Increase of longwalls’ length
- Increase of exploitation progress
- Exploitation of coal seams with higher thickness
  - Increase of methane emissions into exploitation areas

Exploitation under the main haulage level
- Delivering the air to the decline of exploitation areas
- Decreasing of ventilation efficiency and stability of air streams
- Lengthen of the escape roads for the staff
- Methane hazard coming from the goaf
  - Increase of methane and ventilation hazard
Designing of concentrated coal exploitation in the coal panels located in very gassy deposits should be preceded by calculation of the methane emission forecasts together with ventilation analysis, considering effectiveness of methane drainage, concluding with determination of mining capacity of the longwall.

Methane emissions into the environment of the longwall during coal exploitation come from:

- exploited coal seam,
- undermined and overmined coal seams by exploited coal panel, which are within exploitation relaxation zone, having released desorbable methane resources,
- goaf after coal exploitation, which are connected with the exploited longwall environment.
Increase of coal extraction concentration, which can be recognized in Polish hard coal mines in the last two decades, was mainly the result of gradual increasing length of the longwalls, besides – introduction of highly efficient coal shearsers.

The results of the research conducted by Central Mining Institute confirmed, that in the conditions of increasing coal extraction concentration in the gassy coal seams the share of methane emissions into the environment of the longwall coming from relaxed undermined and overmined coal seams is increasing.
Example of mean methane content $M_{5R}$ along the designed coal panel $L_w$
Degree of degassification the exploited coal seam by the shearer depending on its primary methane content $M_0$ (Krause 2009b)

$$
\eta = 18,355 \cdot M_0^{0.5404}
$$

$\eta_s = 56.47\%$

$\eta_s = 33.65\%$

$\eta - \eta_s$

$\eta_s = 8,354 \cdot M_0^{0.67}$

Degree of degassification $\eta_s$ [%]

Methane content $M_0$ [m$^3$CH$_4$/M$\text{dol}$]
Predicted volume of methane emissions into environment of longwall during coal shearer extraction can be calculated based on the following formula:

$$V_{CH_4} = \frac{L_s \, m_e \, \gamma \, z \, M_0 \, \eta_s}{100 \, t}$$  \hspace{1cm} (1)

Where:
- \(L_s\) – length of the longwall, m;
- \(m_e\) – height of exploited longwall, m;
- \(\gamma\) – density of coal, Mg/m³;
- \(z\) – shearer cut, m;
- \(M_0\) – methane content of exploited seam, m³CH₄/Mg_daf;
- \(T\) – duration of coal extraction cycle, min;
- \(\eta_s\) – degree of exploited coal seam degasification – according to formula (2).

$$\eta_s = 8.354 \cdot M_0^{0.67}$$  \hspace{1cm} (2)
Table below presents calculated values of methane emissions into the environment of the longwall during coal extraction cycle. Following longwall’s parameters were assumed:

Longwall’s length $L_s = 250$ m, longwall’s high $m_e = 3$ m, cut $z = 0.8$ m

Primary methane content in the coal seam $M_0 = 8 \text{ m}^3\text{CH}_4/\text{Mg}_{\text{daf}}$.

The calculations were conducted for three durations of shearer’s mining cycle, i.e. : 80 min, 100 min and 120 min. Value $\eta_s$ was calculated based on pattern (2), Methane emissions forecasting into longwall environment during coal extraction was calculated based on pattern (1).

Table 1. Forecasts of methane emissions to longwall environment during shearer operation

<table>
<thead>
<tr>
<th>Duration of shearer’s mining cycle</th>
<th>Predicted methane emissions into the environment of longwall during coal extraction (according to pattern 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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<tr>
<td>80 min</td>
<td>$V_{CH_4} = 26.25 \text{ m}^3\text{CH}_4/\text{min}$</td>
</tr>
<tr>
<td>100 min</td>
<td>$V_{CH_4} = 21.00 \text{ m}^3\text{CH}_4/\text{min}$</td>
</tr>
<tr>
<td>120 min</td>
<td>$V_{CH_4} = 17.50 \text{ m}^3\text{CH}_4/\text{min}$</td>
</tr>
</tbody>
</table>
Vertical cross-section through desorption zones of the longwalls with different lengths
Range of degasification of the overmined and undermined layers depending on longwall’s length and its incline (Krause, Łukowicz 2000)
Vertical cross-section through desorption zone of the longwalls with lengths: L1 and L2; p1, p2, p3, p4 and p5 – undermined coal seams n1 and n2 – overmined coal seams (Krause 2005)
A FIRST FEASIBILITY STUDY FOR COST EFFECTIVE METHANE DEGASSING AND CAPTURE AHEAD OF MINING OPERATIONS TO REDUCE METHANE EMISSIONS IN POLAND DURING MINING (PAWLOWICE 1 COAL FIELD, UPPER SILESIA)

Budget: 340,000 USD, funded by US EPA grant.
Coordinator: Central Mining Institute of Katowice, Ph.D.Eng Jacek Skiba
| T1 | Identification of coal seams to be the target of mining operations |
| T2 | Methane predictions for the planned mining operations |
|    | Design of CBM production and degassing system using surface-bored |
| T3 | wells which include: |
|    | T3.1 data collection |
|    | T3.2 determination of coal reservoir parameters |
|    | T3.3 determination of coal seam continuity (depositional characteristics, structural features); |
|    | T3.4 selection of appropriate drilling technology based on the US CBM experience; |
|    | T3.5 preparation of CBM drilling, completion and production design; |
|    | T3.6 determination of well locations and well spacing; |
|    | T3.7 determination of production volumes using reservoir simulator |
|    | T3.8 determination of methane drainage effectiveness using reservoir modeling techniques; |
|    | T3.9 planning of produced water disposal |
| T4 | Estimation of methane emission reductions |
| T5 | Estimates of the CBM production implementation cost |
| T6 | Review of methane end-use strategies |
|    | Calculating of net revenues and estimating of the CBM production |
|    | project lifetime |
| T7 | Development of an economic model and calculating NPV and IRR |
|    | Converting estimated methane emission reductions to carbon credits |
| T8 | |
| T9 | |
| T10 | Estimates of possible cost savings for the Pniowek coal |
| T11 | Final economic analysis |
| T12 | Conclusions and recommendations |
EPA2 grant
Thank you for your attention

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