Coalbed Methane Development and its Impact on Coal Mining

Part 1

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7 May 2018
Outline

• Background
• Coal Mine Methane
• Considerations for Co-extraction
• Case Studies
• CBM in Poland
Why is methane in coal?

- Methane is a byproduct of physical and chemical changes to organic material that is buried and converted though time by exposure to complex biological and geological processes called coalification.
- Increased temperature and pressure during coalification increases coal maturity (rank), methane is a byproduct of this process, where it is then adsorbed onto the solid matrix of the coal.
Methane storage and migration

- Methane is stored in the coal via this process called *sorption*. Sorbed methane is condensed within the matrix and micropores of the coal and will remain there as long as the pressure is maintained.

- Methane gas can also accumulate in adjacent porous strata such as sandstones, or in naturally occurring fractures.

**Explanation**

\[ V = \frac{V_L \cdot P}{(P_L + P)} \]

- \( V \) = gas content (m\(^3\)/t)
- \( V_L \) = Langmuir volume constant (m\(^3\)/t)
- \( P \) = reservoir pressure (MPa)
- \( P_L \) = Langmuir pressure constant (MPa)

- Anthracite: \( V = 35.96 \cdot P / (2.27 + P) \)
- Bituminous: \( V = 23.89 \cdot P / (3.41 + P) \)
- Subbituminous: \( V = 7.18 \cdot P / (4.35 + P) \)
- Lignite: \( V = 4.42 \cdot P / (6.16 + P) \)
Coalbed Methane (CBM)

- Methane extracted from virgin coal seams
- To recover methane, wells are drilled into the coal seam. As the seam is dewatered, methane desorbs from the coal and flows or is pumped to the surface, where it is either used or transported to market.
- If CBM wells are in close proximity to coal mine, it may serve as a pre-mine drainage well, draining methane from the coal targeted for mining, reducing emissions of methane into the mine.
Development of CBM in the U.S.

• Section 29 Tax Credit (1979 – 1993) incentivized the development of the CBM industry in the U.S.
  – Intended to speed development and production of unconventional gas, mostly in marginal or otherwise uneconomic tight sand, coal seam, and Devonian shale reservoirs
  – Most of the methodologies and technologies to maximize production were developed during this time period.
  – The regions that got the most focus initially were the Black Warrior Basin and the San Juan Basin, two of the most prolific CBM producing basins in the world.
Growth in Unconventional Gas Production in the U.S. 1990-2011

Source: EIA
Coal mine methane (CMM)

- CMM refers to methane and other gases released from coal and surrounding rock strata due to mining activities.
- During the mining process, the strata pressure drops and the gas may begin to desorb, migrating into the coal’s cleats and into the mine’s workings.

In highly gasy mines it is necessary to augment the ventilation system with a degasification system. The gas from the degasification system is often then also emitted to the atmosphere, but can also be used.
The rate and amount of gas released depends on the:

- Initial amount of gas contained in the coal (gas content)
- Coal seam permeability
- Distribution and thickness of the coal seams disturbed by mining
- Strength of the coal-bearing strata
- Geometry of the mine workings
- Method of mining
- Rate of coal production
Benefits of CBM/CMM extraction

- Supply of commercial natural gas
- In-mine methane emissions are reduced
  - Up to 90% of in-seam methane removed
  - Higher coal production rates
  - Reduced loads on ventilation system
  - Increased mine safety
- Greenhouse gas emissions reduced
Co-extraction of coal and methane resources

Coal Mining Life Cycle

Mine Planning
Undeveloped Coal Reserves
- Gas Resources Evaluated and Production Plan Adopted
- Exploration

Active Mining
Developed Coal Reserves
- Gas Produced and Sold During Mining
- Pre-mine and Gob Drainage

Mine Closed
Depleted Coal Reserves
- Enhanced CH₄ Recovery and CO₂ Sequestration
- Post-mining Gas Production

Gas Production Life Cycle
Considerations for co-extraction
Considerations

• Multiple regulatory agencies
  – Ownership
  – Coordination of extraction of both resources
  – Staying out of each other’s way

• Hydraulic Fracturing (fraccing)
  – Design and control of fracture growth
  – Frac fluid use and disposal

• Water management
  – Dewatering
  – Management of produced water
Mineral & surface rights

Ownership rights are controlled by multiple agencies

- Oil and Gas estate is regulated by one agency
- Mining is regulated by second agency
- Surface rights are often controlled by a third entity

Rarely is there coordination between agencies when managing resources.
Fracing near coal mines

Impacts of pre-mine drainage on coal mining

- **USBM RI 9083: EFFECTS OF STIMULATION TREATMENTS ON COALBEDS AND SURROUNDING STRATA - Evidence From Underground Observations** by Pat Diamond & David Oyler
  - “No roof falls or adverse mining conditions were encountered that could be attributed to the stimulations”

- **CSIRO: Sand propped Hydraulic fracture stimulation of horizontal in-seam gas drainage holes at Dartbrook Coal Mine** by R.G. Jeffrey & C. Boucher
  - This full-scale enhancement of gas drainage was successful and allowed efficient mining of that panel...”
Potential impacts of dewatering of coal seams

Advantages

– Lower mining costs
– Use the water for coal beneficiation
– Used for frac fluid

Disadvantages

– Can lead to spontaneous combustion
– If water disposal is required – difficult and costly
  • May require treatment prior to disposal
– Environmental impacts are regulated and must be monitored and mitigated
Potential problems

- Oil and Gas well drilled into active or abandoned mine
  - Loss of drilling fluid into mine workings
  - Flow of gas and water into workings

- Mine into producing or abandoned cased well
  - Active well can be under very high pressure
  - Casing or cement integrity may be problematic
    - Leaks into mine workings

- Surface owner may not own mineral rights
  - Surface owner may have no rights regarding extraction activities, even if adversely impacted
Case Studies
Multiple regulatory agencies and overlapping jurisdiction

- New Elk Coal Mine in Raton Basin in the U.S.
  - Coal mining preceded CBM development
  - Recent coal mining activity must accommodate CBM wells
- San Juan Mine in the San Juan Basin in the U.S.
  - Oil and Gas estate has precedence over coal estate
    - Impacts mine design, rate of mining, and reduces coal reserves
San Juan Mine, New Mexico
Water management case study – Black Warrior Coal Basin

Brookwood and Oak Grove CBM fields

• Both coal and CBM are extracted
• Large volumes of water produced to recover CBM
  – Water is a critical natural resource to economy and energy security
  – Fresh water disposed of in streams for decades – increasing scrutiny from environmental groups/agencies
  – Some produced water may have beneficial agricultural and industrial uses
  – Saline formation water limits ability of CBM producers to pump wells and depressurize coals – thereby leading to underperforming gas production
CBM and/or CMM as renewable resource

<table>
<thead>
<tr>
<th>State</th>
<th>Definition of CMM</th>
<th>Incentives and Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennsylvania</td>
<td>CMM is an alternative energy resource</td>
<td>Alternative Energy Portfolio Standard</td>
</tr>
<tr>
<td>Ohio</td>
<td>CMM is an advanced energy resource; AMM is a renewable energy resource</td>
<td>Alternative Energy Resource Standard</td>
</tr>
<tr>
<td>Colorado</td>
<td>CMM is a renewable energy resource if it is GHG-neutral electricity; determined on a case-by-case basis</td>
<td>Renewable Energy Standard</td>
</tr>
<tr>
<td>Utah</td>
<td>CMM is a renewable energy resource</td>
<td>Renewable Portfolio Standard</td>
</tr>
<tr>
<td>Indiana</td>
<td>CBM (coalbed methane) is defined as an alternative energy source and clean energy resource</td>
<td>Voluntary Clean Energy Portfolio Standard</td>
</tr>
</tbody>
</table>
CBM in Poland
Poland coal basins
CBM Resources in Poland

- USEPA 1991 – Assessment of the Potential for Economic Development and Utilization of Coalbed Methane in Poland

<table>
<thead>
<tr>
<th>TABLE 11. ESTIMATED METHANE RESOURCES OF THE UPPER AND LOWER SILESIAN COAL BASINS (IN BILLION CUBIC METERS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCUMENTED RESERVES, DOWN TO 1000 m</td>
</tr>
<tr>
<td>Developed Deposits</td>
</tr>
<tr>
<td>(Active Mines and Mines Under Construction)</td>
</tr>
<tr>
<td>PROGNOSTIC RESOURCES</td>
</tr>
<tr>
<td>Undeveloped Deposits and Inactive Mines, Down to 1000 m</td>
</tr>
<tr>
<td>Deposits Between 1000 m and 1500 m</td>
</tr>
<tr>
<td>TOTAL RESOURCES</td>
</tr>
</tbody>
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Coalbed methane resource estimates for each mining concession in the USCB and LSCB are shown in Table 6.
CBM Resources in Poland

**Cairn Point Publishing 1997 – The International Coal Seam Gas Report**


<table>
<thead>
<tr>
<th>Coal Basin</th>
<th>Gas Content</th>
<th>Gas In Place</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m³/Mg</td>
<td>CF/T</td>
</tr>
<tr>
<td>Upper Silesian, first estimate(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active mines to 1,000 m (3,280 ft)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Undeveloped coal to 1,000 m (3,280 ft)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Coal at 1,000–1,500 m (3,280–4,920 ft)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Subtotal</td>
<td>≤22</td>
<td>≤705</td>
</tr>
<tr>
<td>Upper Silesian, second estimate(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal to 1,500 m (4,920 ft)</td>
<td>≤20</td>
<td>≤640</td>
</tr>
<tr>
<td>Lower Silesian(3)</td>
<td>≤30</td>
<td>≤960</td>
</tr>
<tr>
<td>Lublin(3)</td>
<td>25</td>
<td>800</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CBM Resources in Poland

2018 Global Methane Forum, UNECE CMM Session: Pre-mine Drainage – Overview of CBM Projects in Poland
There is significant potential for CBM capture in Poland

- Introduce new and/or improved technologies for gas extraction
- Will require establishing new policies and regulations
- Better understanding of coal as a natural gas reservoir
- Develop new energy sources while practicing environmental stewardship
Thank you

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