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Reduction of fugitive methane emissions from open cut coal mines

Frank Hungerford

REDUCTION OF FUGITIVE METHANE EMISSIONS FROM OPEN CUT COAL MINES

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ABSTRACT: Fugitive coal seam gas emissions from open cut coal mines occur when coal and surrounding strata is exposed and fractured as part of the mining process. This liberates the seam gas confined within the coal seams and is a large contributor to the mining industries greenhouse gas (GHG) footprint. Gas reservoir assessment is required to determine the in situ gas content and composition of the coal seams and carbonaceous strata and to define gas zones likely to be targeted in gas reduction drilling. This paper describes the drilling methods and pre-drainage practices and applications available at access and capture seam gas within mining operations. Once captured, methane can be utilised in power generation, fertiliser production, and domestic use or flared to reduce its high environment impact.

INTRODUCTION

Companies are under pressure to reduce their carbon footprint and may in future be forced to do so through legislation. The open-cut coal mining industry has the opportunity to review their operations in a view to reducing their carbon footprint. This should include a study the fugitive seam gas released during mining operations to define all components of a mining operation's footprint (Wasimi, et al, 2022). Open-cut coal mining has been limited to the removal of overburden to depths in the order of 60m. In recent years, overburden to depths of up to 120m have been removed to access more coal resources and with that, higher volumes of coal seam gas have been released. These have been referred to a fugitive gas emissions.

Drilling/drainage practices currently used in underground mining can be utilised to capture the seam gas before it is released into the atmosphere.

The captured gas can then be utilised to reduce the high environment impact that methane has. The challenges with the drilling are with the interactions with mining operations and operating up against an open-cut high wall.

RESERVOIR ASSESSMENT

A reservoir assessment is required to identify key gas sources/zones through the coal measures likely to contribute to fugitive gas emissions. As well as gas being released from the main seam being extracted, gas in the overlying seams (**Figure 1**) will be released as the overburden is blasted and removed. With the reduction of overburden pressures as the overburden is removed, gas in the underlying seams is also able to escape through cracking of the floor of the open-cut mine.

The aim of the reservoir assessment would be to define the gas composition, gas content and likely permeability of the coal seams. Most vertical core drilling in the vicinity would have been for coal quantity and quality assessment without gas content assessment which is usually only included in areas planned for underground mining. Gas content from deeper boreholes can be extrapolated for an initial assessment before more definitive data can be obtained through a targeted surface core drilling program closer to the open cut highwall. As an example, gas content of methane (CH_4) in the Moura area was assessed as 5 m^3/tonne at 100 m depth of cover and 15 m^3/tonne at 500 m depth of cover (Draheim, 1996). An extrapolation of that data (**Figure 2**) provides an assessment of gas content in the coal extracted or disturbed by open-cut mining.

From this assessment, the key zones likely to contribute gas released to the atmosphere can be defined, the composition of the gas defined and the volumes estimated. If the seam gas is CH_4, the likely gas drainage targets for drilling to produce the best drainage effect can be determined. From **Figure 2**, CH_4 content would be approximately 6 m^3/tonne at a depth of 120 m.

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If seam gas is predominantly carbon dioxide (CO2), drilling and capture has no added benefit to greenhouse effect so the aim is to target only CH4 seam gas environments.

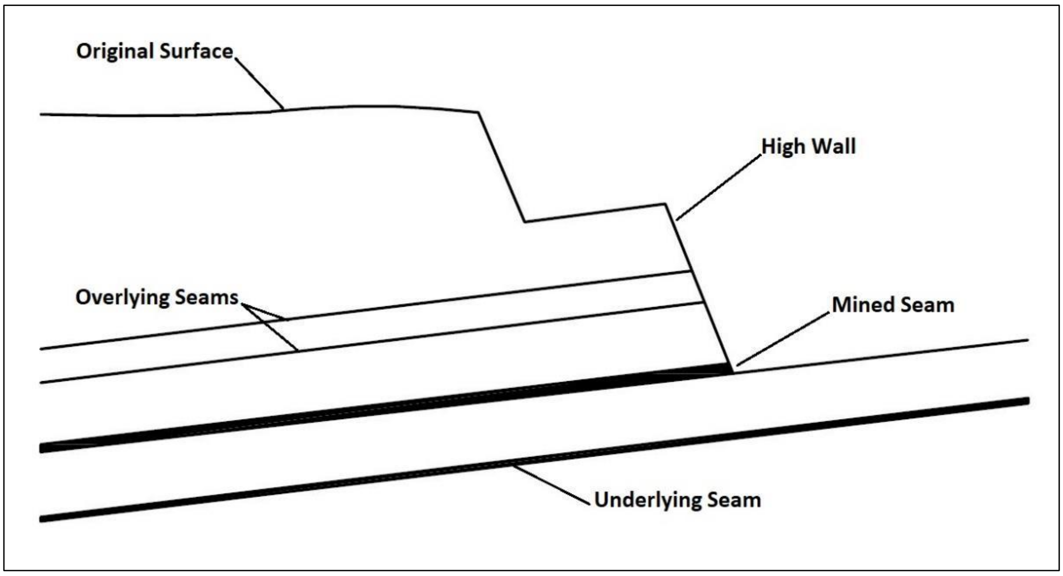

Figure 1: Open cut coal mine profile

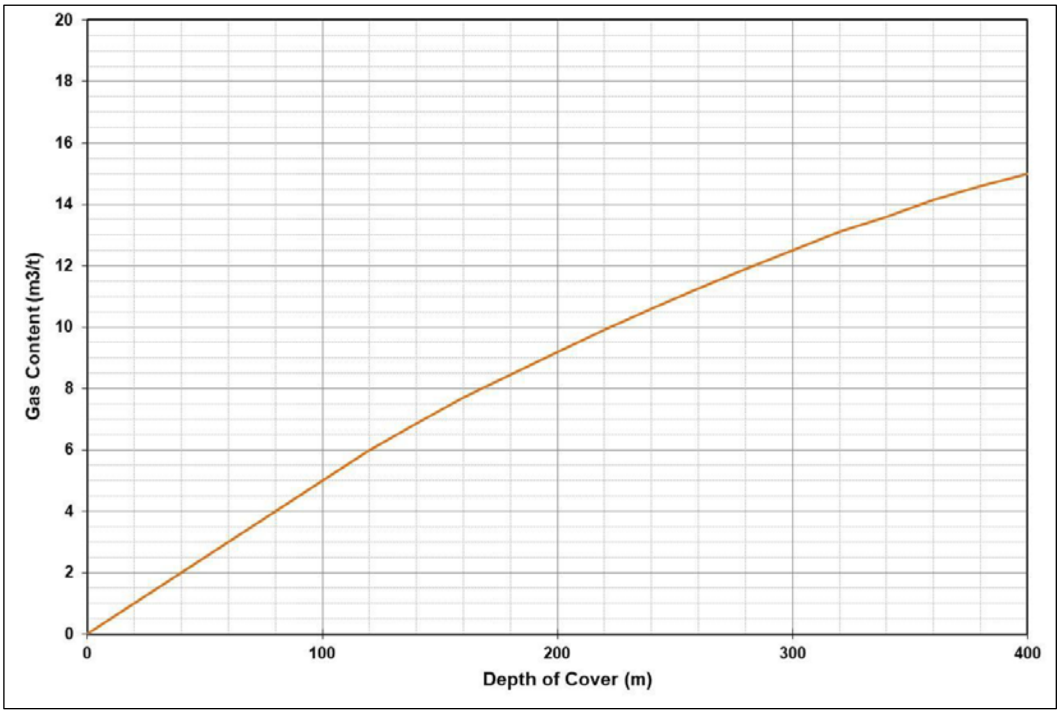

Figure 2: Gas content (CH4) versus depth of cover

DRILLING/DRAINAGE APPLICATIONS

The drilling options available are to either drill into the mined seam from the pit floor into the exposed seam and cross-measure into surrounding gas seams/zones or to drill from the surface (SIS) to access the seam parallel to the open-cut operations. The application used would be determined to suit the geometry of the pit and schedule of the mining operations. The drainage time available between when the high-wall face becomes available for drilling to when that face will be disturbed by the next cycle of mining influences the number, depth and spacing of boreholes. The aim is for gas flow from the boreholes to have diminished to zero before the boreholes are disturbed by the next cycle of mining:

- A short open-cut pit with short mining cycles only allows short, closely spaced boreholes. These boreholes would only cover the width of each mined bench.
- A long open-cut pit with a long mining cycle allows longer boreholes which would produce gas for a longer period. These boreholes can extend across multiple bench widths and remove gas which would not have been released until numerous cycle in the future. This drilling may adequately drain an extended area so the drilling doesn't need to be repeated. This could act to gain gas drainage credits for future years.

Although in-seam directional drilling has been established as a standard procedure which would apply with drilling from the bottom of an open-cut high-wall, the logistics around the drilling operation face numerous challenges unique to the open-cut environment. These include:

- Operating within an active open-cut mine.
- Operating against or in the vicinity of an open-cut high-wall.
- Anchorage of the drill rig to the floor of the open-cut mine. This would be complicated by a need for regular rig moves.
- Installation of a standpipe into the coal face of each borehole before drilling commences.
- Installing gas pipework connected to each borehole within the open-cut pit to collect and transfer the gas toe a management facility. This pipework would have to be removed and reinstalled with each cycle of the mining operations.
- Power supplied by diesel generator.
- Water supply and waste water disposal. There may be an opportunity to recycle the water within the mine.

The key element is operating up against a high-wall with the inherent dangers of rocks falling down the face of the high-wall. The requires a risk assessment referencing the open-cut rules involving working in close proximity of the high-wall to determine how close people can approach the wall and what over-head protection is needed to gain access to the face of the high-wall. That access is required to install standpipes before each borehole is drilled to allow control and capture of all gas issuing from the borehole.

Early drilling from the high-wall at German Creek mine for exploration prior to the development of the Central Underground mine (Hungerford, 1988) employed a shelter (**Figure 3**) over the drill rig. This shelter would not satisfy a risk assessment in the current environment.

Figure 3: In-seam drilling in German Creek open-cut mine (Hungerford, 1988)

Other options may include:

A substantial shed positioned against the face.

A modified shipping container butted against the face through which a pipe extension would connect the drill rig with a standpipe grouted into the face. The drill rig would be positioned some 10-15 m away from the face.

In each case, the drill rig needs to be bolted to the pit floor for anchorage; not having the ability to anchor the rig between seam roof and floor as in underground operations.

The one case of extensive drilling from open-cut high-walls in Australia for CH4 production was undertaken in the late 1990's (Draheim, 1996). In this case, the drill rig was mounted within a very sturdy mobile shed which was designed to satisfy open-cut rules at the time and could be manoeuvred between sites and up against the high-wall. The weight of the structure provided sufficient stability to cater for the thrust loading of the drill rig so no floor bolting was required. The drill rig's power unit was diesel powered. In-seam borehole to lengths of 1200 m were achieved.

Drilling from the open-cut high-wall allows access to both overlying and underlying seams through cross-measure drilling. If the seams are sufficiently thick to contain substantial gas volumes, these seams can also be targeted by drilling to reduce the gas content within them. The same options of short or longer boreholes would apply to satisfy the drainage time allowed by the mining cycle.

UTILISATION

The aim of the operation is to convert the CH4 which would otherwise be released into the atmosphere into CO2 which has a greatly reduced effect on the atmosphere. The Global Warming Potential (GWP) indicates that CH4 has 28 times the impact of CO2, on a long term 100-year time frame (Wasimi, et al, 2022).

Reservoir assessment would give some idea on the volumes of gas likely to be captured. CH4 from initial drilling and drainage would likely be flared while conclusive data was obtained through the drilling program to determine whether adequate gas flows were available to allow investment in ways to utilise the gas and thus off-set some of the cost of the drilling and drainage project.

SURFACE TO IN-SEAM (SIS)

To avoid having to operate within the open-cut mine environment, an option is to consider drilling SIS borehole from the surface to the target seam. The boreholes can be drilled parallel to the open-cut mining operations and continue drainage over extended lead time without being disturbed by the mining operations.

This option would not be able to access and remove gas in the immediate vicinity of the open-cut highway so would be utilised over longer term mining operations.

As an alternative to in-pit in-seam drilling, SIS:

- Would be more expensive per metre drilled.
- Has an ineffective length of borehole to gain access to the seam(s).
- Can access the target seam parallel to the high-wall face allowing longer boreholes for longer drainage times.
- Can access the coal measures all over the lease independent of open-cut operations.
- Boreholes can be dewatered to improve gas flows.
- Gas utilisation pipework can be relatively permanent and confined to centralised drilling locations.

COST COMPARISON

When considering the mode of drilling operations to be utilised, the cost needs to be considered:

High-wall drilling is likely to be cheaper but have shorter effectiveness and complicated by interaction with open-cut mining operations. If longer boreholes can be employed over longer drainage periods, the in-seam drilling may not have to be repeated.

SIS drilling more expensive but boreholes can be active for longer and not require as much drilling.

CONCLUSIONS

Gas drainage drilling ahead of open-cut mining operations accesses a gas resource not previously utilised. When set up to open-cut requirements, the in-seam drilling is an established practice.

By accessing and capturing seam gas previously identified as fugitive gas emissions, there is the potential to reduce the carbon footprint of each open-cut mining operation. This would likely allow each open-cut coal mine to satisfy any future legislation requirements.

Although the drilling and capture of the seam gas would present an additional cost to the mining operations, utilisation of the captured gas could provide an additional source of income to offset that cost.

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