Underground CMM Capture and Emission Reduction - a case study

Dr Hua Guo, GMI Coal Mines Subcommittee Best Practices Workshop

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Introduction

A major research project under the auspices of the Australian Government Coal Mining Abatement Technology Support Package (CMATSP)

Objective

To develop a holistic and optimal approach of planning, design and operational control of coal mine methane drainage and ventilation systems to maximise methane capture and minimise fugitive emissions in gassy and multiple seam conditions

Collaborative parties

– Bulga Underground Coal Operations, Glencore (formally Xstrata)
– Coal Mining Research Program, CSIRO
Project Scope

- **Extensive site characterisation** of in-situ strata, hydrogeological and gas conditions
- **Systematic field measurements and monitoring** of mining induced strata, ground water and gas changes at and around longwall panels
- **Continuous monitoring** of goaf gas pressure and composition changes
- **Comprehensive 3D numerical modelling studies** to develop a fundamental understanding of mining induced strata, groundwater and gas behaviour
- **Assessment** of key parameters in gas drainage design and operation
- **Development** of design methodology for optimal and practical gas drainage systems
- **Implementation and demonstration** of new drainage systems
Site Characterisation

Site geological and mining conditions characterised

– Geology and hydrogeology
– Gas reservoirs and gas bearing parameters
– Mining and gas drainage technical data
– Gas drainage operational data
– Mine ventilation
Extensive Monitoring and Measurement

- Strata deformation and stress changes
- Gas reservoir pore pressure changes
- Goaf gas flow dynamics
- Goaf gas pressure and composition changes
- Longwall ventilation gas levels
- Gas drainage performance
- Pre and post mining gas content measurement
- Borehole stability and integrity inspections
Monitoring Results

Overburden movement

Seam pore pressure changes

Vertical well stability

Effect of well location on drainage preformation
Key Observations

- Mining induced fractures and delamination extended up to all overlying coal seams in 36 m above the longwall
- Coal seam pore pressure decreased quickly between 50 m outbye and 100 m inbye of the longwall face
- Gas drainage boreholes were often blocked 30 m above the mining seam
- Sources of gas emissions are Redbank Creek and Wambo seams in the roof, and Glen Munro in the floor
- Gases stored in overlying Whyrow goaves did not flow down into the active goaf
- Vertical wells located in tailgate side of goaf within 30 – 80 m performed much better than those located in mid panel and main gate side
Coupled Numerical Modelling

- Using CSIRO’s COSFLOW code
- Calibrated by field studies
- Coupled modelling of strata, water and gas
Coupled Numerical Modelling continued...

- 3D distribution of strata stress, fractures and permeability
- Gas emission patterns
- Annular zone of relatively high de-stressing and high permeability observed
- Critical input for subsequent CFD simulations
CFD Simulations

- Study goaf gas flow patterns and dynamics
- Based on site characterisation and measurements
- Calibrated by site ventilation and drainage data
Examples of modelled lateral borehole arrangements

- Gas flow and capture dynamics
- Optimisation of borehole quantity, diameter, location, patterns
- Different combinations of 5 horizontal holes located within 30-110 m from tail gate with a diameter of 150 mm simulated
Horizontal Post Drainage Through Goaf Gas Pressure Control

- Create low pressure sinks that protect workings from gas flowing into ventilation by changing goaf gas flow directions
- Produce consistent gas flow rate and concentration
- Efficiently reduce methane levels in workings
Optimal Goaf Gas Drainage Design

- Laterally located at tailgate side into annular high permeability and methane rich zone
- Vertically located in lower fractured zone above caved zone
- Floor lateral holes into Glen Munro to reduce gas from flowing up to goaf
- 150 mm holes to reduce friction loss and maintain flow rate
Trial at LW4 in 2014

- Trialled at initial mining stage (400 m retreat) at LW4
- 5 roof lateral holes and 5 floor lateral holes, 400 m long lateral section
- 15-22 m above mining seam
- Roof lateral holes reamed to 145 mm in diameter
Trial Results - Improved Gas Capture Performance

- Drainage performed much better than conventional method
- Stable gas drainage flow rate
- Lower ventilation methane levels
- Reduced fugitive gas emissions

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<th>Vertical gas drainage only</th>
<th>Horizontal + vertical drainage</th>
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**Vertical and Horizontal gas drainage**

- **Total gas captured**
- **Return CH4%**
Trial Results –
Increased Drainage Efficiency

- Gas capture efficiency was increased to 80%
- Annual fugitive emission reduction estimated at 0.42 Mt CO₂-e (compared to LW3)

### Longwall 3 Specific Gas Emissions from real time monitoring

<table>
<thead>
<tr>
<th>Week Ending</th>
<th>Longwall Retreat</th>
<th>Longwall Tonnes</th>
<th>Total seam gas m³</th>
<th>SGE l/s aver.</th>
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### Longwall 4 Specific Gas Emissions from real time monitoring

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<th>Longwall Retreat</th>
<th>Longwall Tonnes</th>
<th>Total seam gas m³</th>
<th>SGE l/s aver.</th>
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Trial Results – Improved Mining Safety and Coal Productivity

- Significant reduction of gas related coal production delays
- Significant increase of coal production in initial mining stage (an increase of 79% from LW3)
Trial Results – Methane Utilisation and Emission Reduction

• Methane captured by the floor lateral holes was utilised by a 9MW power generation unit (capacity: 850 l/s)
• Methane captured by the roof lateral holes from goaf was incinerated by three (3) goaf flares (total capacity: 4,500 l/s)
Application at LW5

- Following the successful trial at LW4, the mine has replaced the surface vertical goaf drainage system with underground lateral holes at the entire panel of LW5.
- The floor lateral holes were not implemented due to site constraints.
Result of LW5 Gas Drainage in 2015

- Roof lateral holes performed well at LW5
- Roof lateral hole gas flow rate and daily coal production were 1252 l/s and 22,411 t on average, close to that in the trial at LW4 (1279 l/s and 23,121 t)

LW5 drainage CH4 flow rate to 15/03/2015 (retreat of 398 m)
Conclusions

• The largest integrated study of field investigation, numerical modelling, and CFD simulation

• Important insights into the coupled strata, gas and groundwater behaviour in complex multi-seam longwall mining that are critical to optimal goaf gas drainage design and emission reduction

• The new gas drainage system, consisting of underground horizontal holes into roof and floor seams, was designed, trialled and applied successfully at the mine in 2014 and 2015:
  – Gas drainage efficiency improved
  – Gas related down time reduced substantially (by 2 months each year)
  – Annual net fugitive emissions reduction estimated by up to 0.42 Mt CO$_2$-e
The success of the optimal gas drainage system demonstrated that the scientific gas drainage design methodology used in this study is reliable and effective:

- Comprehensive site characterisation including geology, hydrogeology, strata and gas reservoir conditions
- Field studies to determine key information such as gas emission sources and drainage targets
- Coupled numerical modelling to determine 3D gas flow environment
  - Goaf and surrounding strata conditions of destressing and fracturing
  - Annular zone of high permeability and rich methane
  - Gas emission patterns
- CFD simulation to test and optimise gas drainage design
Acknowledgements

The project team would like to thank the Australian Department of Industry and Science for funding this research. We would also like to express our gratitude to the management and staff of Glencore Bulga Underground Operations for their great support, and CSIRO colleagues for their contributions.
Thank you

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