Applications of in-seam drilling and methane drainage at Central Colliery, Bowen Basin

by

M. Caffery[1], S. Smith[1], B.B. Beamish[2], B. Robertson[3], R. Phillips[1] and P. Crosdale[2]

[1]Capricorn Coal Management Pty Ltd [2]Coalseam Gas Research Institute [3]The Shell Company of Australia Limited

ABSTRACT

Capricorn Coal Management Pty Ltd (Capcoal) has been investigating and developing appropriate and cost-effective techniques for limiting the impact of gas emission on mining at its Central Colliery operation. A strategy has been developed to establish the level of data collection and reporting required prior to and during methane drainage of the 306 longwall block using longhole in-seam drilling. In addition proposed investigations by Capcoal personnel and outside research groups are foreshadowed.

This approach is aimed at providing the necessary information to:

1. assess the geological environment and coal reservoir characterisitics

2. assess drilling performance

3. assess drainage effectiveness.

These criteria will provide a measure of the overall effectiveness of the project. In addition, a quantitative measure of drilling performance and drainage effectiveness will form the basis for further improvements in drilling technique and drainage patterns.

INTRODUCTION

Capricorn Coal Management Pty Ltd (Capcoal), a wholly owned subsidiary of The Shell Company of Australia Limited, operates an opencut and two underground mines at German Creek (Figure 1) in Central Queensland's Bowen Basin. Central Colliery commenced production in 1984 and a longwall was introduced in 1986. Southern Colliery began development in late 1987 with longwall mining commencing in December 1989. Coal from these production centres is blended and prepared for the export coking coal market.

Both underground collieries are located in the German Creek Seam, of the German Creek Formation, which dips to the east from subcrop at 5-7°. Methane gas is contained in the virgin seam at increasing concentrations with depth. Initially mining activities were carried out at shallow depths but as mining progressed downdip, increasing levels of methane emission were encountered. Southern Colliery will experience low gas emissions for several years, whereas Central Colliery has already encountered significant levels of methane emission at depth.

A series of 265m long in-seam boreholes are being drilled into 306 longwall block (Figure 2), to confirm the viability and effectiveness of full scale seamgas drainage at Central Colliery. A small scale drainage program in 305 longwall block showed the potential for effective drainage at Central Colliery (Phillips, 1992). The current drainage program is using downhole motor drilling technology and borehole surveying to provide good drilling control, to maintain borehole location within seam and to enhance seam definition. This technique has proven successful throughout Australia in recent years (Williams, 1991; Hungerford *et al.*, 1988; Williams *et al.*, 1986), and even in extremely difficult seam conditions overseas (Beamish *et al.*, 1991a).

The key to the viability of this program is two-fold:

1. To optimise drainage coverage requires good drilling control.

2. To assess drainage effectiveness requires good seamgas drainage characterisation.

This paper makes comment on both these areas, which must be treated as complementary.

BACKGROUND AND DRAINAGE PROJECT OBJECTIVES

The increasing gassiness of the 300's longwall blocks has been well documented from both underground measurements (Robertson *et al.*, 1989), and surface borehole cores (Jeffrey, 1992). As mining advances into deeper reserves beyond 305 MG, the *in-situ* gas content increases with depth from 7 m^3/t at 250 m depth to 12 m^3/t at 400 m depth. This compares with 305 MG where gas contents ranged from 5 m^3/t at 2 East to 8 m^3/t inbye of 17 c/t.

The trial gas drainage program in 305 MG demonstrated that coal can be successfully drained so as to allow development to proceed with reduced interruptions due to gas emissions. This program was able to lower the gas content from 8 m^3/t to 4 m^3/t inbye of 17 c/t in 305 MG, during the course of a six month drainage program.

The following project objectives have been identified for the 306 longwall block program:

1. To undertake a dedicated drilling program to pre-drain 306 MG development and 306 longwall block to enable mining to proceed at acceptable rates.

2. To drill a series of parallel and fan layout holes to a design spacing, and direct the methane into an underground pipe range.

3. To lower the gas content to 3 m^3/t, requiring up to 6 months drainage time.

4. To measure the gas flow to determine the level of drainage achieved and purity of drained gas.

5. On completion of gas drainage, to grout the inbye end of the hole and water infuse that section covered by the longwall block.

6. To undertake the project in a safe and cost effective manner.

GENERAL PROJECT DESCRIPTION

Initial preparations included the installation of a drainage range along the 305 MG roadway, which was then connected to a surface borehole for venting the drained gas from the workings.

Drilling, gas collection and flow measurements

Drilling of 44 parallel holes, 265 m long, from 305 MG and intersecting the proposed 306 MG development is in progress. Further holes will be drilled in a fan pattern inbye of 21 c/t 305 MG to pre-drain the extension of 306 MG. The total drilling is expected to be 17,000 metres.

Gas collection and flow measurements include the following:

1. placement of a tube to the back of each hole to enable borehole dewatering and free flow of methane.

2. installation of gas/water separators and flow measuring apparatus at the hole collar.

3. connection of the hole delivery hose to the drainage mains.

4. regular measurement of gas flow purity.

Upon the completion of gas drainage it is proposed to grout the downhole section of those holes which transect the development alignment for the next panel. The remainder of the hole will be water infused for a period of time to replenish the moisture of the coal. This will assist towards reducing the dustiness of the longwall block during mining.

PROJECT MONITORING AND CONTROL

Geotechnical Environment

Comprehensive geological support in the following areas has been identified to enable the maximum benefit to be gained from the 306 longwall block Methane Drainage Project. This includes:

1. Consideration of all existing geological information from drilling, testing and mapping viz:

- coal types
- borehole locations
- structure, seam thickness,
- German Creek Upper interburden
- faults, dykes, shearing in seam and roof
- cleat and joint density and orientation
- coal fracture detail
- brightness maceral logging

2. Additional detailed mapping and specific site studies and sampling of:

- seam gas content and permeability
- quality and maceral correlations
- sorption isotherm from samples

3. Testing of rib sub-samples from 305 MG for gas adsorption/release characteristics.

4. Collect drill cuttings (and cores) at selected locations from drilling program for sorption testing (dependent upon success of 3).

Other options for possible implementation are:

5. Installation of piezometers in existing vertical boreholes over 306 longwall block. This will require the isolation of German Creek seam and the monitoring of seam gas pressure decay with dewatering.

6. Drill in-seam observation holes to:

- install piezometers and monitor gas pressure fall
- collect post drainage gas content data.

7. Repeat mapping/sampling/testing exercise during development of 306 MG and longwall extraction of 306.

8. Test the distribution of water infusion using RIM techniques.

9. Conduct reservoir simulation modelling to match drainage performance, simulate alternative drainage options for future applications to 307 block.

Drilling Performance

The in-seam drilling is being performed by Strata Drilling with assistance from Capcoal personnel. Drill hole log sheets and shift reports are being completed by the drilling contractor in a manner that captures the maximum amount of information necessary to quantify both drill performance and seam characteristics. The drill log includes information on drill penetration rates, notes on drill cuttings, gas surges, and other 'first hand' observations which could assist with coal seam characterisation. Information collected is entered into a computer database for analysis. The shift report is a measure of contract performance and provides detail on all activities performed and lists any delays with their causes.

Ground conditions in the area to be drilled are generally good with roadway ribs indicating a reasonable degree of stability. However, the presence of two shear zones in the seam makes it necessary to monitor drilling performance closely in the vicinity of these features.

The primary coal fracture direction is at an angle of approximately 45° to the main drilling direction. In rotary drilling there is a tendency for borehole deviation to occur, influenced by coal structure. Downhole motor drilling does not normally encounter the same problem. It will be necessary to monitor any lateral deviation in boreholes in response to this situation.

Seam Drainage Effectiveness

The overall assessment of the drainage effectiveness is considered to comprise the following components:

1. Collection and analysis of gas drainage data including gas flow, pressure, purity and water make during the drainage period.

2. Post drainage analysis and assessment of pre-development seam gas conditions.

3. Collection and analysis of gas emission data and related mining performance during development of 306 MG.

4. Analysis of water infusion effectiveness by dust monitoring during the extraction of 306 longwall block.

5. Analysis of gas emission data and related mining performance during extraction of 306 longwall block.

Possible Seam Profile Effects on Drainage

The presence of the mid-seam shear zone poses major questions on drainage effectiveness. This coal ply subdivides the seam into three distinct sections. How does gas drain from each of the seam sections? Does the shear zone act in-situ as a barrier between the upper and lower parts of the seam or is it so permeable as to act as a major gas flow conduit? Does the upper seam section drain faster than the lower seam section or vice-versa?

If the sheared coal is present as a rapidly desorbing material, then major gas surges will result when it is encountered in the borehole. The facility to shut-in the borehole during drilling is a necessary precaution, which has already been attended to.

The use of a self-dewatering device in the borehole reduces the possibilities of blockages, as material breaking off the side-wall is swept to the bottom of the borehole by the one-way gas flow. Also, in the event of a blockage, the device can be used to re-flush the borehole.

Degassing/dewatering effects on coal

It is well documented that degassing of coal removes water from the seam to the point of creating dusty coal conditions during mining (Hargraves and Lunarzewski, 1985). Therefore, it is important that water flow rates are monitored and plotted against gas flow rate. The dusty coal situation can be rectified to a degree with re-infusion of water.

Water flow monitoring.

Influence of cleat

Directional permeability in response to cleat has been documented for other in-seam drainage programs in the Bowen Basin (Beamish *et al.*, 1985) and from laboratory studies (Bartosiewicz and Hargraves, 1985). Boreholes drilled perpendicular to the primary coal fracture direction generally show higher gas flow rates. The majority of boreholes in this program will be drilled at 45° to this direction, which will provide a good intersection coverage of both the primary and secondary coal fracture directions. Fan drilling is to be conducted at the inbye end of the block. This will allow a comparison of flow rates with change in borehole orientation to the cleat direction.

DRAINAGE SIMULATION

Input parameters and resultant outcomes for a drainage simulation are presented in Table 1. The analysis presented covers the 2km x 265m main block and does not include the fan drilling area. Assuming uniform drainage cover has occurred, the following results are obtained:

1. To drain the coal to a required level of 3 m^3/t in 180 days will require an average gas flow of 2.4 l/min/m for each borehole.

2. The corresponding average daily gas volume to be handled would be 41,222 m^3/day.

3. To obtain an equivalent drainage effect, in the same timeframe, with surface boreholes could require 10 wells flowing at 140 Mcfd, based on field trials conducted to date in the Bowen Basin.

COLLABORATIVE WORK

Recent research at the Coalseam Gas Research Institute has established a testing facility capable of assessing the gas flow characteristics of coal samples in detail (Beamish *et al.*, 1991b), down to the microscale. As a result, key distinctions have been recorded in the behaviour of dull and bright coal types. The coal microstructure plays a significant role in this respect (Gamson and Beamish, 1991).

The technology being developed at CGRI is ideally suited to in-seam drilling programs, which utilise a downhole motor. The cuttings flushed from this type of drilling are of a suitable size for testing (both gas sorption and fracture analysis). This reduces the added expense of coring, as is usually the practice. Information on coal fracture frequency, nature and gas flow characteristics can all be related back to the seam profile locality (assuming surveying of the borehole is routinely practised).

The information obtained from such a program will provide substantial long term benefits in the areas of mine safety, productivity, gas recovery and utilisation. As part of a recently funded project by the New South Wales Joint Coal Board Health and Safety Trust future testing is to be conducted in conjunction with the drilling/drainage program. The main aims of the work are:

1. To investigate the gas flow characteristics of German Creek coal.

2. To identify differential gas flow horizons in the seam to assist optimum drainage.

3. To identify proximity to seam dislocations and disturbances.

In-situ measurements of coal permeability, reservoir pressure and desorption pressure are being made by CSIRO, Division of Geomechanics for input to model simulations of gas flow. Additional advice on drainage characterisation and drilling has been supplied by ACIRL and GeoGas Pty Ltd.

It is hoped that the development of a model which accurately predicts drainage behaviour will facilitate optimisation of future drainage practices.

A simplified drainage simulation for longwall block 306 indicates the average gas flow rate needed to reach a drainage target level of 3 m^3/t is 2.4 l/min/m. It has also been indicated that for vertical well degasification to be effective will require greater lead times and good gas production performance.

CONCLUSIONS

The routine recording and plotting of survey data to provide borehole profiles is crucial to successful drilling and drainage. Updating of structural and seam information enables a better optimisation of drilling resources in the next borehole to be drilled. The major geotechnical problem in defining the drainage effectiveness will be as a result of differential gas desorption from the seam profile. There are two scales of viewing this problem:

1. Seam profile sections - Upper seam - midseam shear - lower seam: Definition of drilling through upper, lower or shear zone intervals will be necessary to monitor any differential flow effects. This may be achieved either by recognition of change in cuttings (size, rate, colour - look for mineralisation associations) or drilling rate and bit pressure.

2. Coal type banding effects: The differential desorption/diffusion displayed by dull and bright coal bands will also influence the gas flow rates from the seam. This can be assessed by laboratory testing using the specialised equipment available at CGRI, supplemented with borehole definition and drainage response.

The effect of borehole blockages will also need assessing if they are found to occur.

The presence of differential desorption from the seam will also impact on gas emissions during mining. Data from core desorption and borehole pressure tests, prior to mining, will help identify poorly drained areas. Such areas should also be readily identifiable by maintaining a rigorous gas monitoring program as mining progresses.

The compilation of results at the completion of the drainage program can be used in a cost benefit analysis, to assess competing in-seam drainage options as well as to compare with alternative drainage techniques (e.g. vertical well degasification). This analysis will assist future mine planning in several areas:

1. To increase mine safety by reducing gas emissions.

2. To assess an optimum drilling strategy (borehole spacing, length, location in-seam).

3. To consider appropriate options for seam-gas utilisation.

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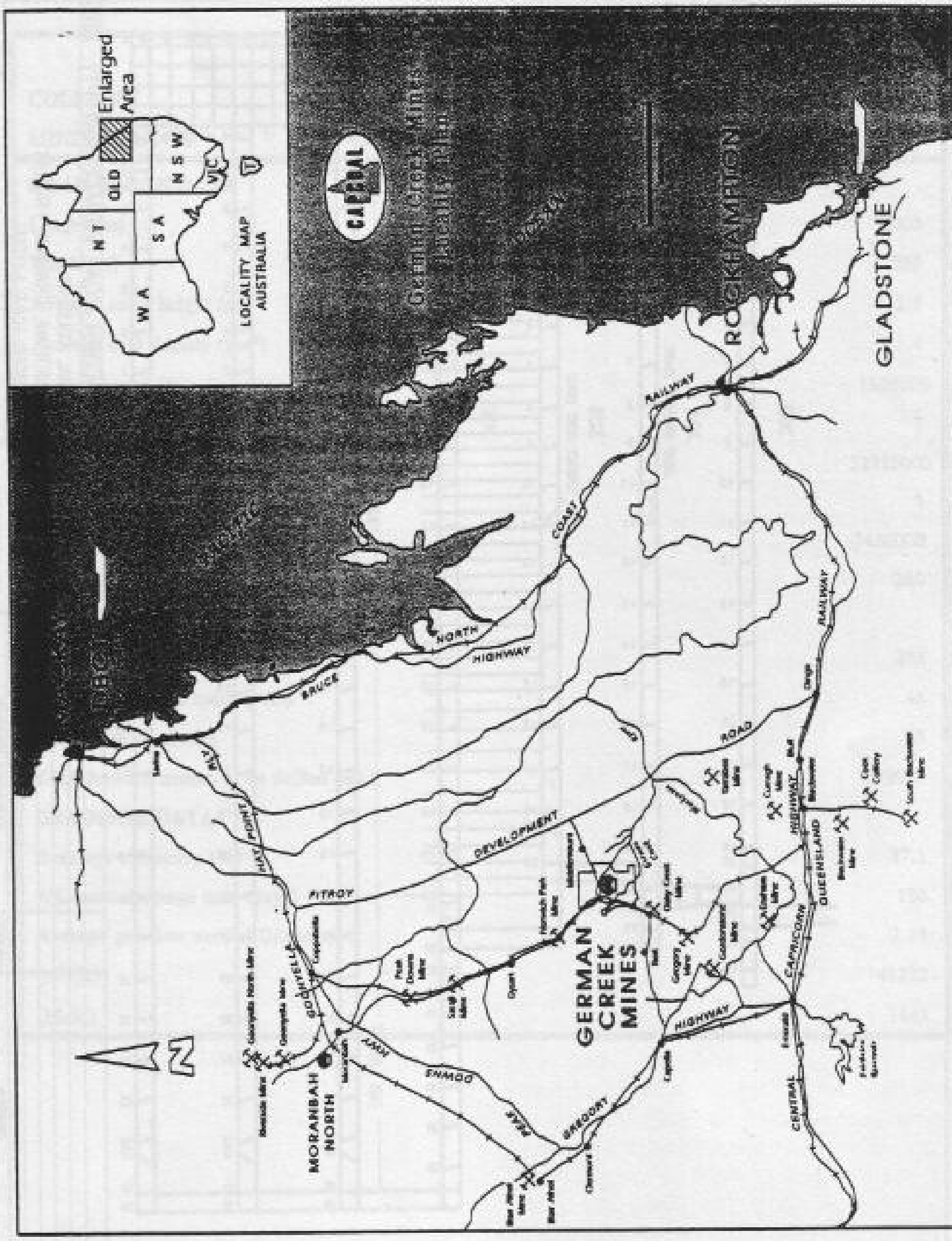

Figure 1. Location map of German Creek Mines.

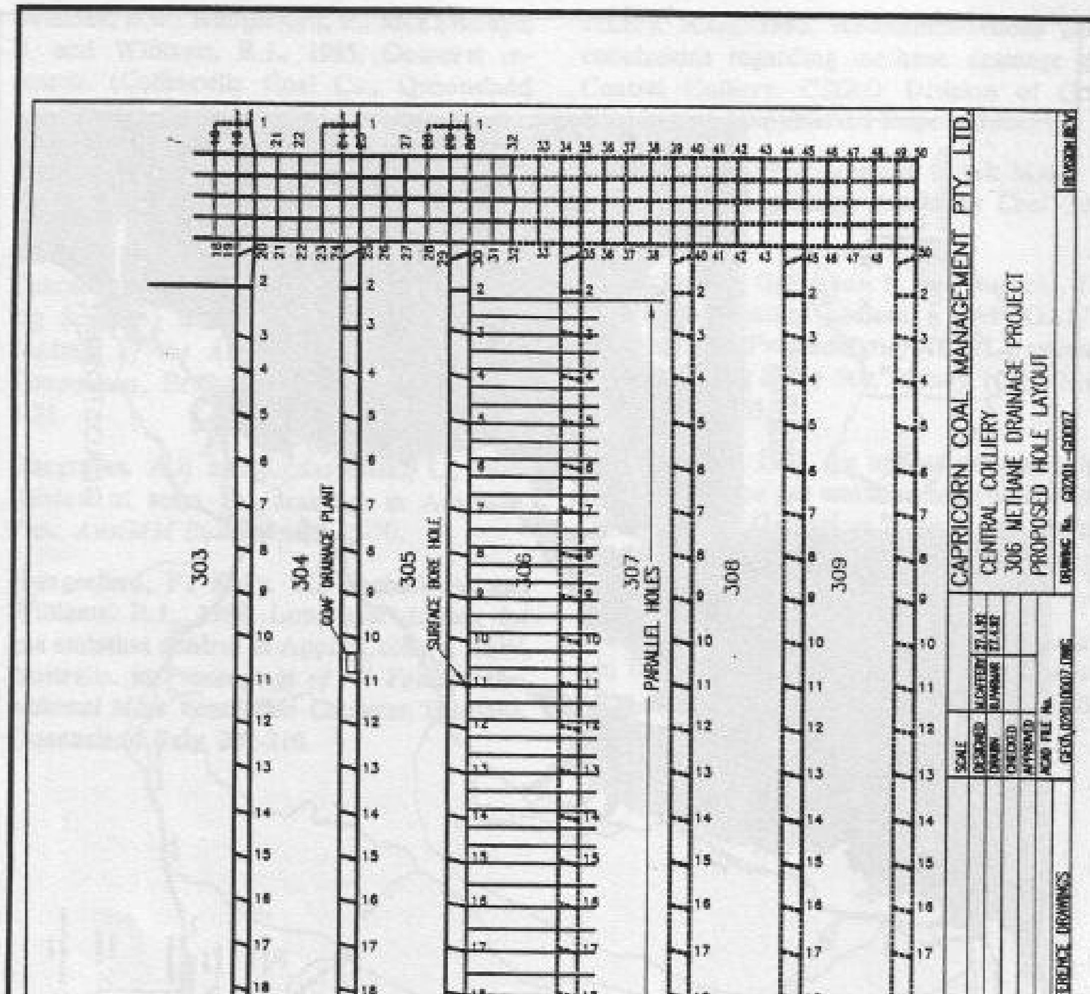

Figure 2. Central Colliery 306 methane drainage project proposed hole layout.

	GAS DRAINAGE SIMULATION
COLLIERY	Central Colliery, Capricorn Coal Management Ltd.
MINING BLOCK	LWB 306
COAL BLOCK DATA	
Length (m)	2000
Width (m)	265
Average seam height (m)	2.5
Average coal density (t/m³)	1.4
Coal resource (t)	1855000
Average gas content (m³/t)	7
Gas resource (m³)	12985000
Required gas content (m³/t)	3
Gas to be drained (m³)	7420000
(MMcf)	260
DRILLING DATA	
Average borehole length (m)	265
Average borehole spacing (m)	45
Number of boreholes	45
Total forward metres to be drilled (m)	12043
DRAINAGE DATA	
Drainage efficiency (%)	57.1
Allocated drainage time (days)	180
Average gas flow needed (l/min/m)	2.38
(m³/day)	41222
(Mcfd)	1443

Table 1. Simulated results for gas drainage/drilling at Central Colliery.