# CAPTURE GAS FROM LONGWALL GOAFS

Xue S, and Balusu R
CSIRO Exploration and Mining
PO Box 883, Kenmore, QLD, Australia 4069

**ABSTRACT**
In gassy underground coal mines, capturing gas from active longwall goafs has traditionally been a challenge for mine operators to control high gas emissions in longwall faces. More recently, the mine operators have been encouraged to shoulder the responsibility of exploring the utilisation options of the captured gas from the goafs to mitigate the greenhouse gas impact. To enhance the utilisation options, the captured gas should have a relatively consistent flow quantity and quality. This task of capturing gas from active longwall goafs to control longwall gas emission and to maintain a consistent flow quantity and quality is quite challenging, however it has proven to be possible in some cases by applying an effective goaf gas capturing technique. This paper will present the successful application of the technique, in terms of its effective control of gas emission at longwall face and consistent quantity and quality of the captured gas, in a gassy underground coal mine in Australia.

## 1.0 INTRODUCTION

In gassy underground coal mines, the gas from coal seams (working seam and nearby overlying and underlying seams) has to be partially drained to prevent outburst of coal and gas and to control gas emission during coal extraction. Capturing seam gas using pre-drainage techniques have proven to be very difficult in some mines because of the low in-situ permeability of their coal seams. To overcome the problem, mine operators have been using various post drainage techniques to capture gas released after the strata has been disturbed by coal extraction. Among the post-drainage techniques, cross-measure technique and surface goaf hole techniques are the most common used to capture gas from longwall goafs in Australian coal mines. Because applying the surface goaf hole technique does not interfere with longwall mining, this technique tends to be applied in a mine where there are few restrictions on surface access and mining depth is not too deep (less than 450 m).

To effectively capture gas from longwall goafs with the surface goaf hole technique and maintain a consistent flow quantity and quality of the captured gas, it is critical to gain a fundamental understanding of the gas flow mechanics of longwall goafs in order to have an optimum design, location and spacing of the surface goaf holes.

An investigation of the gas flow mechanics in longwall goafs incorporates a number of complementary studies including field measurements of goaf gas distribution and monitoring of changes with face retreat, gas drainage flow variation studies, tracer gas studies and theoretical studies using computational fluid dynamics (CFD) modelling techniques. Based on the comprehensive investigation of the gas flow mechanics in longwall goafs, this paper will present the design, location and spacing of the surface goaf holes, its effect on longwall gas emission, as well the flow quantity and quality of the captured gas from the longwall goafs of a gassy underground coal mine in Australia.

## 2.0 MINE BACKGROUND

The mine investigated is one of the gassiest mines in Australia. The underground mine produces about 2.5 Mt coal per year and operates a single longwall face and three continuous miner sections. The mine layout is primarily a two-entry gateroad system, except near the mains. The longwall faces are 200 m wide, with panel length ranging from 1,000 around 2,500 m. Gateroad pillar width is about 35 m with cut-throughs normally spaced at 100 m intervals. Two surface exhaust fans are used to supply about 220 m3/s of air into the mine at 2.1 KPa pressure.

The working coal seam has an average thickness of 2.5 m and contains about 15 m3/t gas at the current mining depth of about 420 m. There are three coal seams within 100 m above the working seam and one seam within 30 m below the working seam. Indications are that there are fair amounts of gas contained in these overlying and underlying seams. The seam gases are predominantly methane with carbon dioxide and nitrogen making the minor parts of the seam gas.

## 3.0 GAS ISSUES

Potential gas hazards such as gas ignition, explosion, and contamination are principle hazards at the mine. The potential for a gas related hazard at the mine is considered to be high. Mine gas management plan is implemented to prevent or minimise the potential gas hazards. The control measures used for prevention include the consideration of the gas issues in mine design and ventilation, environmental monitoring, and mining systems. Gas drainage (inseam pre-drainage and longwall goaf drainage) is developed and implemented as an integral part of the mining systems in the mine.

The inseam pre-drainage system aims to reduce the inseam gas content to a minimum possible level prior to mining. It utilizes a fan pattern of 90 mm diameter holes drilled 40 – 60 m apart that are connected via an underground pipe range to a surface borehole. This layout of regularly spaced holes drains the gas from the working seam in advance of development and longwall extraction.

Longwall goaf drainage system aims to drain the longwall goaf reservoir to minimise gas content in the longwall panel and return during and after mining.

The goaf drainage is achieved with large diameter boreholes drilled into the caved strata behind the longwall face. These holes capture the gas released from the overlying strata and coal seams.

In spite of the implementation of gas drainage programme, the mine was still presented with the face gas emission during longwall extraction. The face gas emission data and the performance of the gas drainage systems were analysed. The results of the analyses indicated that further improvement in gas pre-drainage efficiency and mine ventilation system was possible, however, it might be not adequate or economically sustainable. Instead the focus should be centred on draining more goaf gas with the longwall goaf drainage system by optimising the design of the goaf holes. Furthermore, the consistency of the quantity and quality of the gas captured from the longwall goafs should also be considered wherever possible to enhance its utilisation options. The specific tasks investigated include the following stages: (I) the detailed study of gas flow mechanics in the longwall goafs, (II) design of surface goaf holes to control based on the knowledge obtained in stage 1, (III) assessing the effect of the goaf drainage with new design of goaf drainage holes on the gas emission in the longwall panel, and (IV) analysing the performance of the flow rate and composition of the gas captured from the longwall goafs. Outcomes of the 1$^{st}$ stage of work have been discussed in detailed in a paper by Balusu et al (1992). The following sections will report the results of the 2$^{nd}$ and 4$^{th}$ stage studies.

## 4.0 <u>DESIGN OF SURFACE GOAF HOLES</u>

Goaf drainage using surface goaf holes involves drilling vertical boreholes from the surface above longwall panels to capture gas from coal seams in the roof strata disturbed by coal extraction, as shown in Figure 1.

Key design parameters of the surface goaf holes include: location, diameter of the hole, slotted casing length, suction pressure and flow capacity of goaf plant, spacing of holes, and number of holes in operation at a time.

The location of goaf holes on the longwall panel has major influence on gas flow performance. Site-specific caving and subsidence characteristics of longwall panel determine the optimal location of the goaf holes in relation to gateroads and panel margins. Studies indicate that goaf holes drilled near gateroads produce more gas for a longer time compared with centre line holes on the same panel. As the strata near the gateroads & panel margins are partially supported by pillars and in under tension, it will have enhanced fracture permeability. This also allows the fractures at these locations to stay open for a longer time than those in the centre of the panel do, where complete subsidence and re-compaction occurred relatively quickly. The studies have led to repositioning of the goaf holes from the traditional centre line location to locations closer to the margins of the panel. It should also be noted that goaf holes should not be placed too close to the gateroads in which case excessive amounts of mine ventilation air may be drawn into the goaf holes.

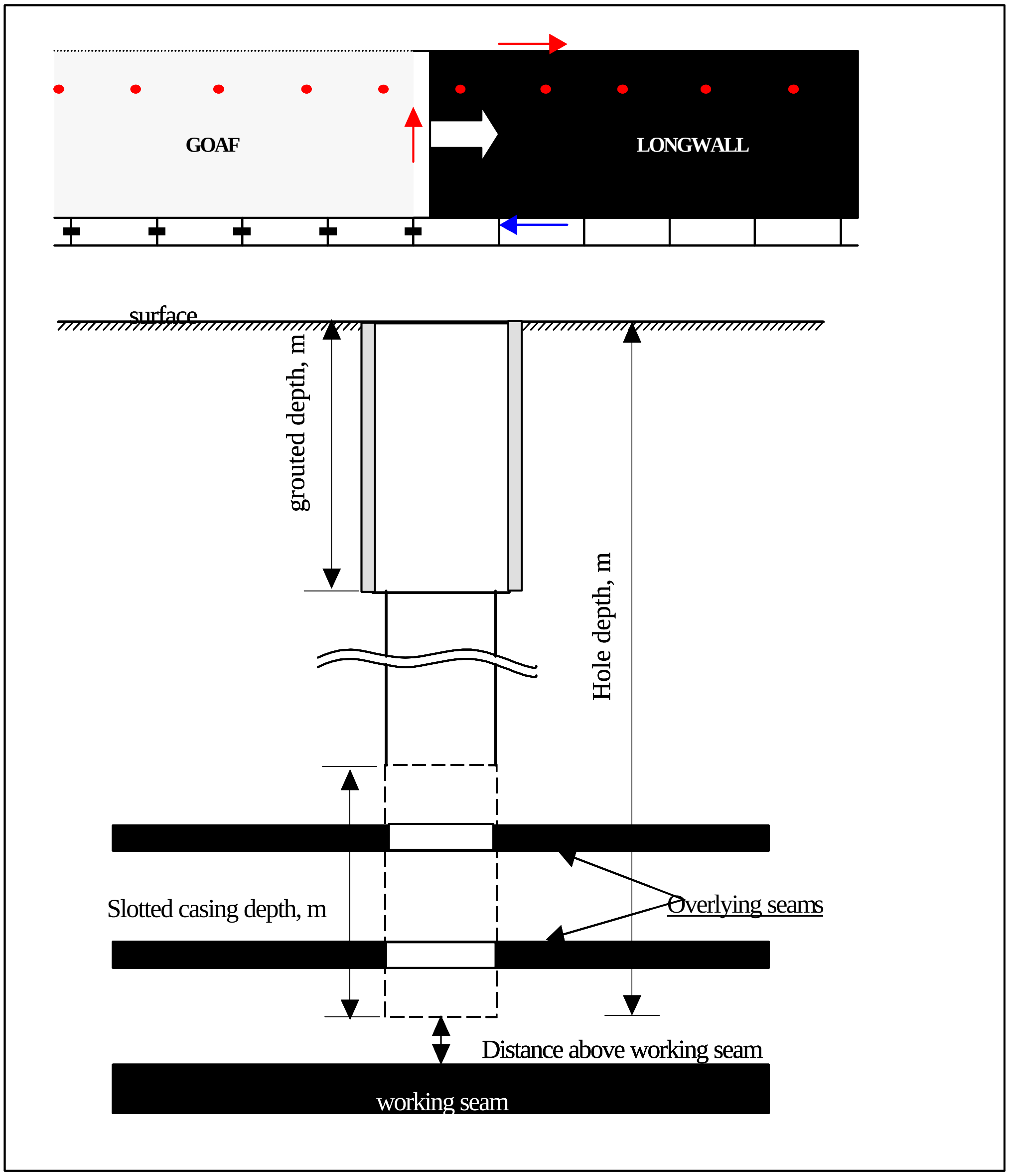


Figure 1 Surface goaf holes

Diameter of the goaf hole depends on gas emission from the longwall goafs, depth of workings and suction capacity of the goaf plant. Length of slotted casing is another important factor, as it will have an influence on gas composition and total flow of the goaf hole depending on goaf gas distribution. The goaf holes will usually produce only a small volume of under natural flow conditions. The holes are typically equipped with exhausters/goaf plants to drain gas from the goaf. Suction pressure and flow capacity of the goaf plant in turn depends on diameter of the hole, buoyancy and ventilation pressures around the goaf.

The spacing between the goaf holes and the number of holes required is determined by site specific mining conditions, such as rate of mining and goaf gas emissions. When conditions are stable from panel to panel, the goaf holes may be drilled several months in advance at specified intervals. However, when conditions are not stable, the spacing for the hole is based on mine gas emission rates as panel progresses.

Numerous variations on the basic design of goaf holes are possible. To find an optimal design for particular conditions, flow modelling and field investigation may be used. Table 1 summaries the studies undertaken for the design of the goaf holes in the mine investigated.

Table 1 Design of goaf holes and the relevant studies undertaken

| Design parameters | Studies undertaken |
|---|---|
| Location<br>Spacing of holes<br>Diameter of the hole<br>Slotted casing length<br>Goaf plant – suction pressure & flow capacity<br>Number of holes in operation | Field investigations<br>- Goaf gas distribution monitoring<br>- Tracer gas studies<br>- Face gas profile monitoring<br>- Surface goaf hole tests<br>CFD modelling studies<br>Caving modelling studies |

## 5.0 <u>PERFORMANCE OF SURFACE GOAF HOLES</u>

With the new sets of design parameters of surface goaf holes, not only the gas emission in the longwall face was significantly reduced, the consistency of gas flow quantity and quality from the longwall goaf was also achieved.

High gas emission was one of the major delays in longwall production. Since the goaf holes with new sets of design parameters were implemented, the gas delay has been greatly reduced. The gas emission in longwall panel (excluding drainage) has been reduced to around 375 l/s with average, which can be easily handled with the mine ventilation system.

The performance of the gas from the surface goaf holes is continuously monitored and recorded. The results show that the pure methane flow rate from the goaf drainage holes averages around 1200 l/s, as shown in Figure 2. This constitutes about one third of the total gas make in this mine (the other two thirds are captured with pre-drainage and mine ventilation systems). The results also indicate a fairly consistent gas flow rate during the extraction of the longwall panel in the mine.

The oxygen concentration of the gas from the surface goaf hole is shown to be around 3%, as shown in Figure 3. There is little fluctuation in the oxygen concentration throughout its operation. The methane concentration has been maintained between 60 to 90%.

The consistency of methane flow rate and concentration in the captured gas from the longwall goaf, among other parameters, is of major importance in enhancing its utilisation options such as power generation.

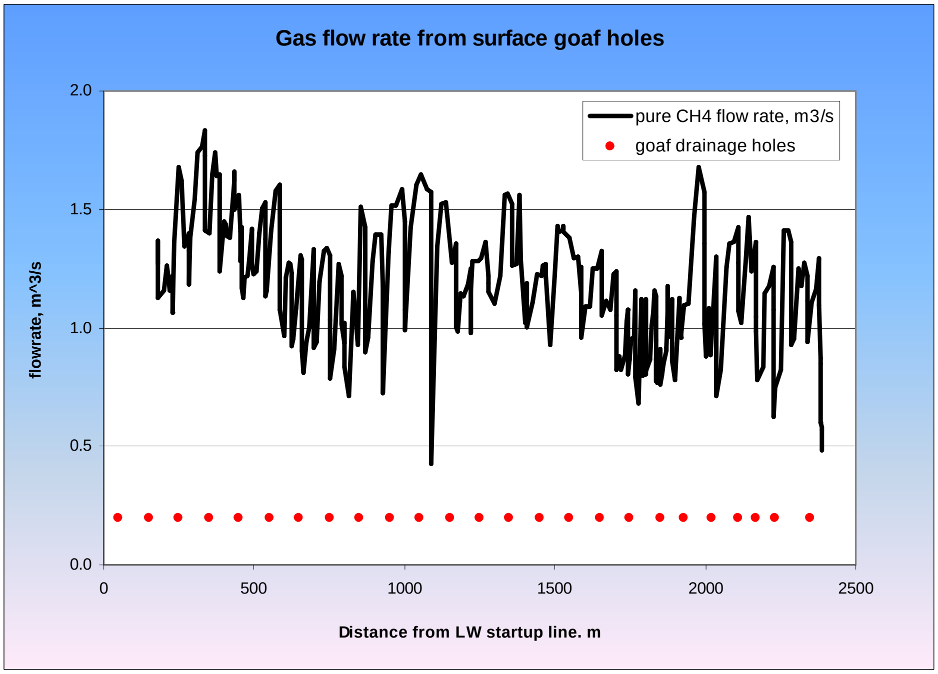


Figure 2 Gas flow rate from surface goaf holes

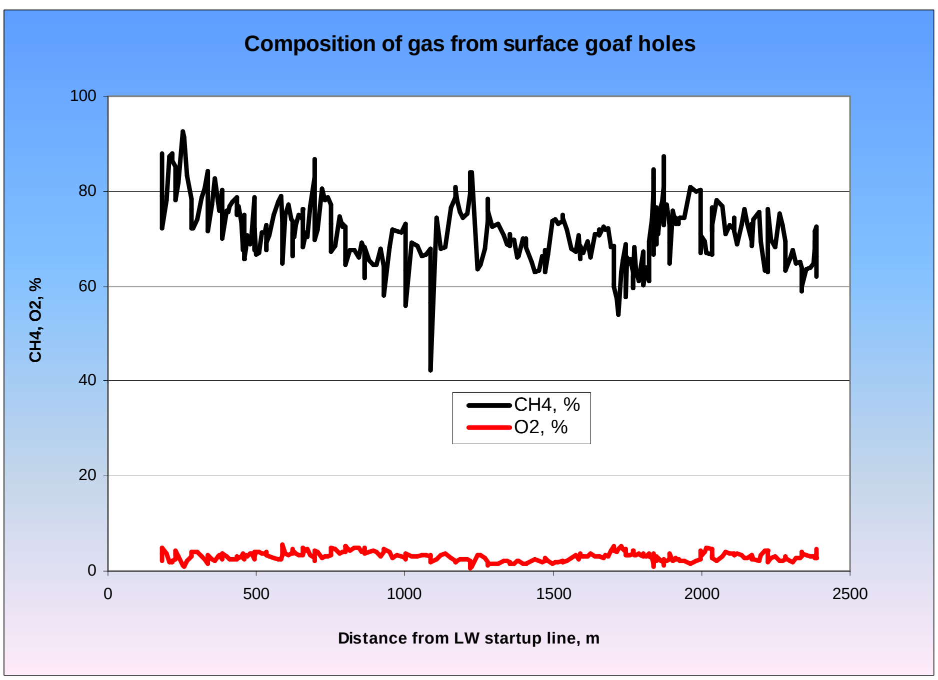


Figure 3 Gas compositions from surface goaf holes

## 6.0 CONCLUSIONS

This study shows that with an optimal design of surface goaf holes it is possible in some cases not only to control high gas emission at a longwall face but also to maintain a fairly consistent flow quantity and quality of the captured gas from the holes to enhance its utilisation options.

## 7.0 REFERENCES

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