2001

Gas Emission Modelling of Gate Road Development

R. J. Williams
GeoGAS Systems Pty Ltd

E. Yurakov
GeoGAS Systems Pty Ltd

D. J. Ashelford
GeoGAS Systems Pty Ltd

Publication Details

This conference paper was originally published as Williams, RJ, Yurakov, E & Ashelford, DJ, Gas Emission Modelling of Gate Road Development, in Aziz, N (ed), Coal 2001: Coal Operators' Geotechnology Colloquium, University of Wollongong & the Australasian Institute of Mining and Metallurgy, 2001, 45-51.

GAS EMISSIONS MODELLING OF GATE ROAD DEVELOPMENT

BY RJ WILLIAMS, E YURAKOV AND DJ ASHELFORD

GAS EMISSION MODELLING OF GATE ROAD DEVELOPMENT

R J Williams, E Yurakov and D J Ashelford

Managing Director, Senior Gas Reservoir Engineer, Mining Engineer
GeoGAS Systems Pty Ltd,
139 Kembla St, Wollongong, NSW 2500

ABSTRACT: This paper covers the modelling of gas emission during gate road development. Complexities related to the range of gas reservoir and mining data are briefly described. The rib emission response to initial gas reservoir parameters is defined using the SIMED II gas reservoir simulator. The rib emission decay curves are then used in an interactive EXCEL spreadsheet model that takes additional account of mining and ventilation parameters. It is an attempt at bringing to planners and mine operators an interactive tool that incorporates the important parameters and options.

SIMED's strengths lie in it's ability to:

- quickly convey a message that facilitates action toward improved ventilation and/or gas drainage design and implementation.
- contain all the important gas reservoir and mining parameters within a manageable package.

INTRODUCTION

The sensitivity of mining to gas emission is rising, with planned production rates in excess of 6 million tonnes per annum, increasing gate road lengths (> 4 km), wider longwall faces (to 350 m), thick seam mining and higher gas content coal. For long gate roads, supplying sufficient air to support auxiliary fans can be problematic, and is particularly sensitive to the number and quality of cut through seals. The added leakage from shorter cut through spacings (e.g. 60 m) in support of place changing can be significant. This burden is increased where intake bleed air is required for cooling conveyor belt tripper drives.

A high gas environment may not be able to support large capacity auxiliary fans given the limitations on intake/return pressures and air loss due to leakage through stoppings. Limitations in the ability to supply face air quantities through long gate roads and associated leakage result in gas drainage being required sooner than would be the case for shorter gate roads.

From a mine planning point of view, the following information is required:

- Intake gas concentration at the start of the hazardous zone
- Gas concentration in the face area
- Gas concentration in the return at the beginning of the panel
- Intake/return ventilating pressure difference at the start of the panel
- The quantity of air entering the panel that will meet the requirements for auxiliary ventilation and gas dilution.

In addressing these requirements, both gas reservoir and mining parameters need to be considered. This paper broadly outlines GeoGAS's approach to gate road gas emission modelling for assessment and control.

PARAMETERS TO BE CONSIDERED

The rate of gas emission into a mine roadway is initially dependent upon the following main, gas reservoir characteristics:

- Measured gas content (Qm) at reservoir temperature
- Gas desorption rate

- Gas composition
- Gas sorption capacity at reservoir temperature
- Seam thickness and mineral matter (ash/density)
- Permeability (including directional) and relative permeability
- Pore pressure
- Coal porosity and compressibility

These parameters and their measurement are described in Williams, Casey and Yurakov (2000).

Gas reservoir characteristics in the Sydney and Bowen Basins can be highly contrasting. Where seams dip significantly (Bowen Basin, Hunter Valley), mining is conducted in a rapidly changing gas environment. Normally, permeability decreases with depth while gas content increases. These depth gradients can vary considerably (Figs. 1 and 2), even between adjacent areas from the same coal seam.

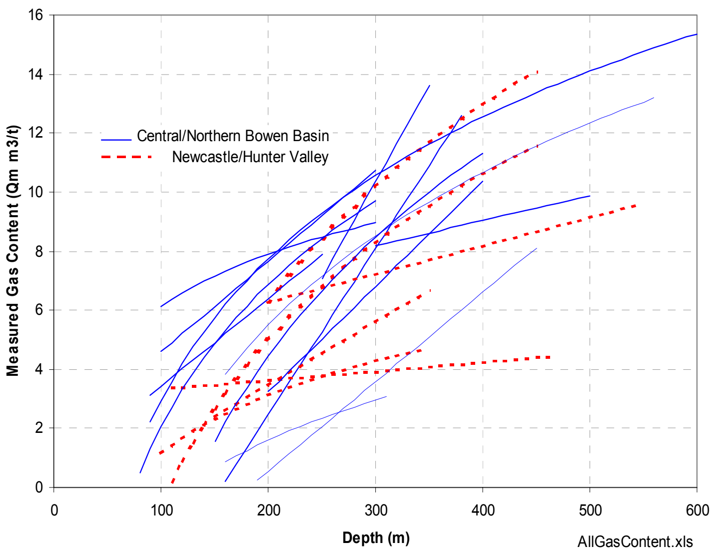

Fig. 1 Example Actual Gas Content Gradients

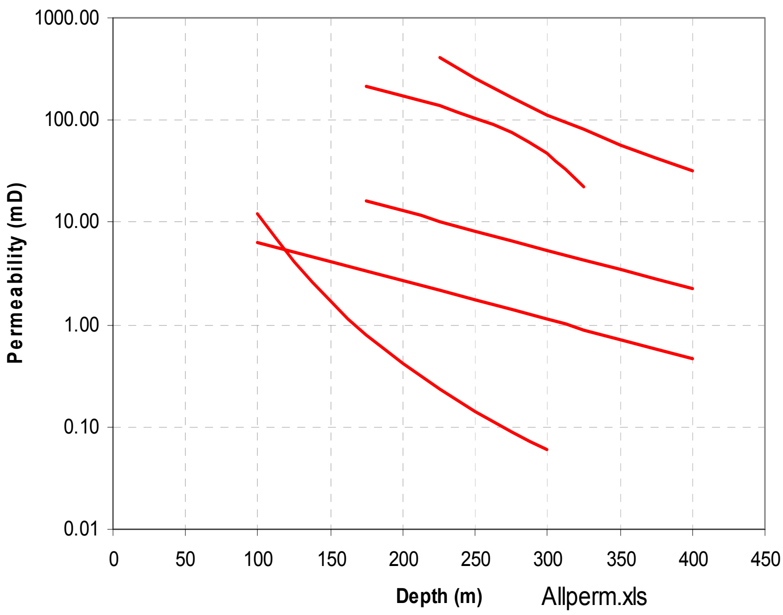

Fig. 2 Example Actual Permeability Gradients

Creation of the mine opening results in reduction in pore pressure, gas desorption and migration of gas toward and into the mine roadway. The rate of gas emission is dependent upon the above gas reservoir parameters, including the geometry of the mine roadways and their proximity to one another. The SIMED II gas reservoir simulator is used to define the time dependent rib emission decay curves.

SIMED II is a two phase (gas and water), three-dimensional, multi gas component (i.e. CO_2, CH_4 N_2 etc) with simultaneous modelling capabilities, single or dual porosity reservoir simulator. The dual porosity capability is used for coal seams, simulating the slow, concentration gradient driven, desorption from the coal matrix, and the pressure gradient flow of gas through the fracture network.

Gas content alone is a poor indicator of likely gas emission. The combined effect of permeability, gas content and seam thickness require gas reservoir modelling to define the emission outcome. Gas emissions (rib emission) can be just as high at low gas contents (e.g. 3 m^3/t) as at high gas contents (e.g. 15 m^3/t), with the reduced gas content compensated by higher permeability and thicker coal environments (Fig. 3).

The rib emission decay curves importantly define the rate at which gas will be emitted into a roadway, according to its age. The effect of varying the rate of mining (panel advance) is readily calculated from the decay curves. The result is still not realistic, requiring the inclusion of ventilation parameters and related geometry. Mining related parameters are:

- Number of headings (two or three)
- Panel length
- Geometry of the excavation (height, width, number of roadways, pillar width and length)
- Rate of panel advance
- Air quantity supplied to the start of the panel
- Roadway friction factors
- Stopping resistance

The last three factors determine the amount of air that will be supplied to the last open cut through.

Emission in the face area combines rib emission (according to the rib emission decline curves), with emission from cut coal. It is a snap shot of mining just prior to the cut through holing, at a time when the auxiliary fans are at their highest duty. The emission from cut coal is dictated by desorption rate characteristics of the coal, adjusted for lump size. Mining related parameters are:

- Face cutting rate
- Time for cut coal in the face area
- Mean cut coal lump size
- Pillar width
- Roadway drivage rate
- Shifts per day mining
- Days per week mining

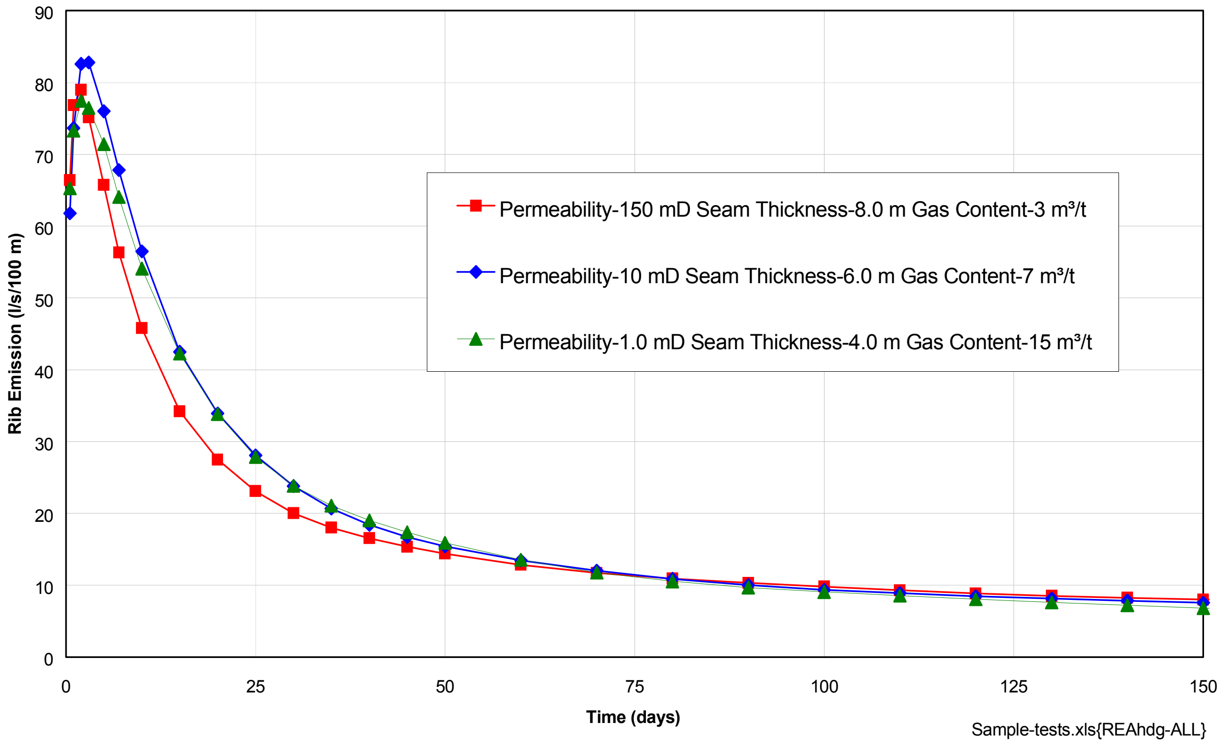

Fig. 3 Rib Emission Decay Curves Showing Compensating Effects Between Gas Content, Permeability and Seam Thickness

THE MODEL

SIMED II uses fundamental numerical modelling to generate the rib emission decline curves. That achieved, the curves in themselves are still of little direct use to mining. An EXCEL spreadsheet model incorporates the SIMED derived rib emission curves and adds the effect of ventilation related parameters, mining rate, number of headings, face gas emission. With so many options and variables to be appraised, the EXCEL model has been designed for interactive use by mine personnel.

There are always varying degrees of uncertainty in the data. Provision is made to account for this by providing "High", "Mean" and "Low" emission options that apply to rib emission decay curves, reflecting combinations of gas reservoir parameters modelled by SIMED. A more rigorous account of uncertainty can be done by using probability modelling within the EXCEL spreadsheet (e.g. using the EXCEL add on package "@RISK").

The greatest amount of time and care is usually required in specifying parameters for SIMED modelling. A common situation is a gate road developing down dip, with changing gas content, seam thickness, permeability, pore pressure and gas desorption rate. Along the line of the intended gate road, these parameters are graphed (example Fig. 4). To make the SIMED modelling work manageable, the gate road is divided into regions where the gas reservoir parameters have been averaged. For the case in Fig. 4, three regions have been defined.

The resulting rib emission decay curves for each region's set of gas reservoir parameters are incorporated into the EXCEL model. The model can chart the gas emission as the panel is developed. When development passes from one region to another (e.g. from Region A to Region B in Fig. 4), a different set of rib emission decay curves is invoked.

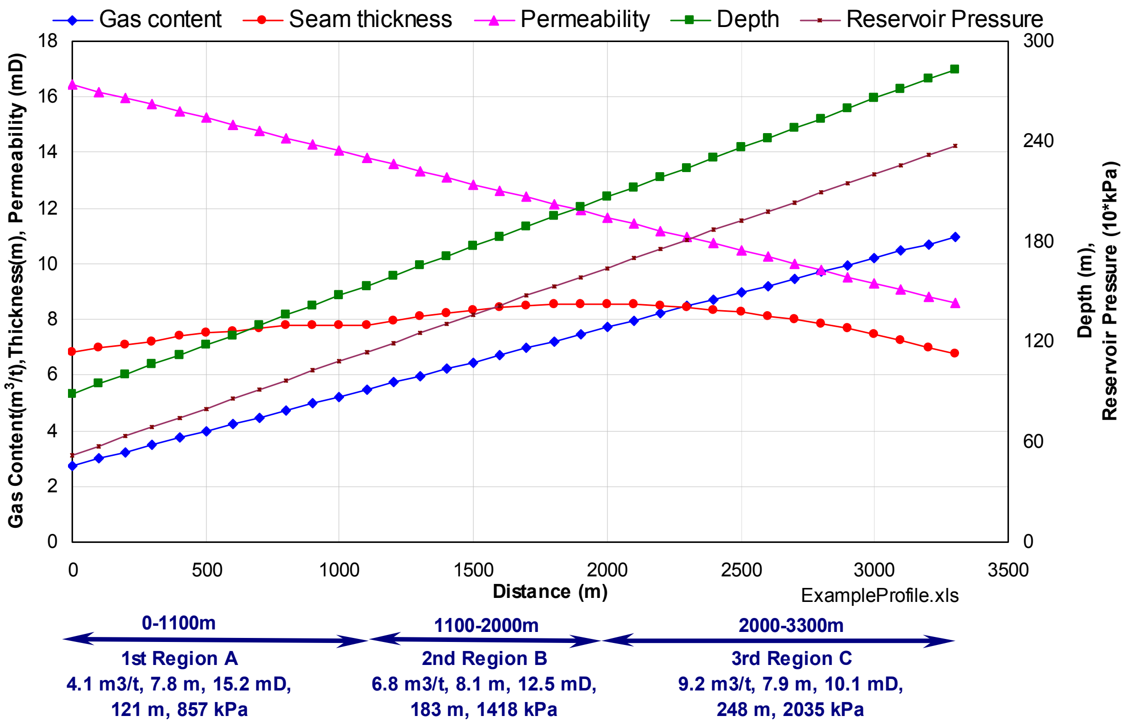

Fig. 4 Example Gas Reservoir Parameter Profile Along an Intended Gate Road

The main input and output work-sheet ("Emission" Fig. 5) shows a range of results including gas emission, gas concentration and ventilation quantities at preset locations specific to planning and statutory requirements, according to the options selected and values used. In this example, the emission decline curves used in the third region are for coal predrained to 4 m^3/t.

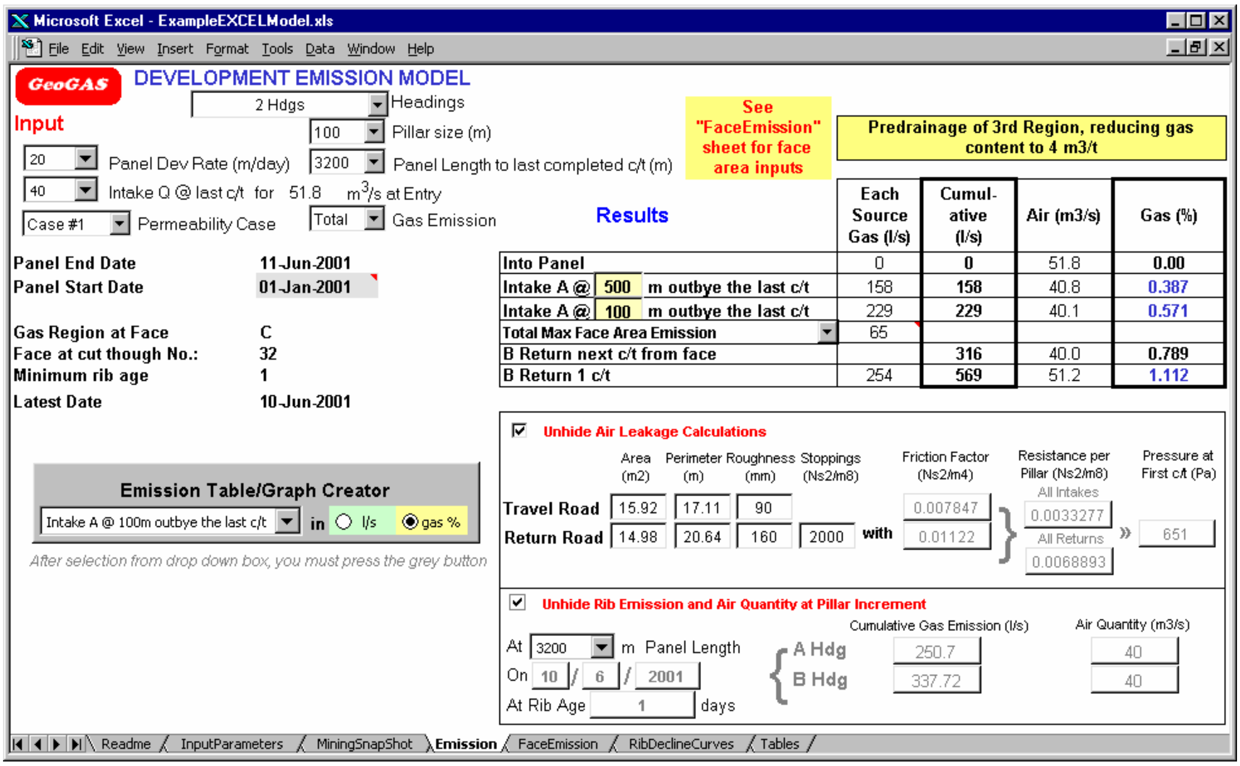

Fig. 5 Example of Interactive Worksheet "EXCEL" Model

The "FaceEmission" work-sheet (Fig. 6) allows for peak mining rates in the face area. It is independent of the rate of panel advance outbye the face area, where the rate of mining ("Panel Dev Rate (m/day)", Fig. 5) refers to total panel advance in calendar days.

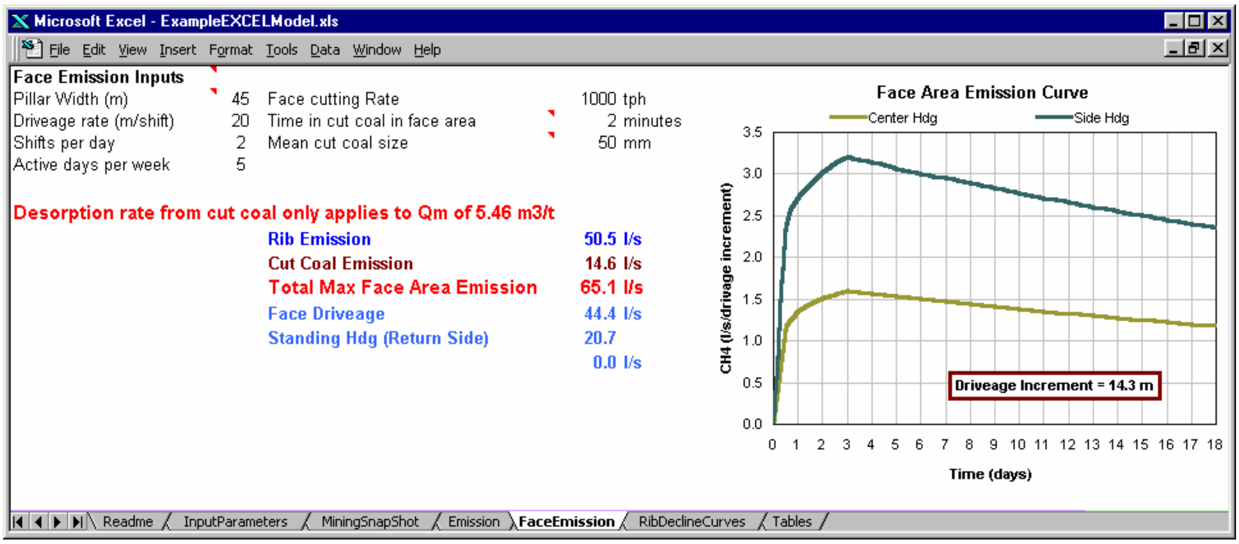

Fig. 6 Face Emission

CONCLUSIONS

Gate road gas emission assessment is highly complex, with a range of gas reservoir and mining parameters needing to be considered. The modelling approach, beginning with SIMED II and being completed as the EXCEL spreadsheet interactive model is an attempt at bringing to mine operators and planners a tool that can incorporate all the important parameters and options into a manageable package.

While it has been widely applied in New South Wales and Queensland validation through back analysis largely remains to be undertaken. The face emission aspect is the weakest part of the model, and ideally requires hard data (continuous return gas monitoring results), to better specify parameters.

For now, its strengths lie in its ability to:

- quickly convey a message that facilitates action toward improved ventilation and/or gas drainage design and implementation.
- contain all the important gas reservoir and mining parameters within a manageable package.

REFERENCES

Williams, R, Casey D and Yurakov E, 2000. Gas Reservoir Properties For Mine Gas Emission Assessment, *Bowen Basin Symposium 2000, The New Millennium – Geology Proceedings,* Rockhampton, Queensland, 22-24 October 2000, pp. 325-333