

# A New Approach in Planning Gas Drainage Practices

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## ABSTRACT

Both safety and productivity in underground gassy coal mines can be improved substantially if an appropriate gas management system is introduced. A strong direct relationship exists between the gas emission rate, roof and floor strata relaxation zones characteristic, mining activities and gas drainage practices. Detailed knowledge of geological factors, gas and coal-rock properties, as well as mining systems are necessary for the methodology used in predicting overall underground gassiness, and planning gas capture and ventilation systems. Early gas emission calculations for various mining activities, particularly for the longwall mining system are essential. A reasonably accurate prediction of gas make as well as the design of ventilation, gas recovery (drainage holes) techniques can be made using 'Floorgas' and 'Roofgas' computer simulations, provided sufficient geological, mining, and gas data are made available.

## STATE OF THE ART

Several techniques for predicting gassiness during longwall coal production have been developed. Many are only relevant to regional mining, gassy and geological conditions. Most methods adopt the same basic parameters: the stratigraphy above and below the seam, insitu gas contents of the working and adjacent seams, the strata relaxation coefficient, and the degree of gas liberation. The accuracy of the final results, however, depends substantially on individual coefficients, which are developed specifically for the above techniques, and therefore cannot be reused in other mines or regions (countries). Comparative test results, using various coefficients, have shown that large errors are possible in these methods, within the range of -50% to +120% (Dunmore, 1979).

The advent of computer modelling methods, and particularly finite element techniques, enables predictions based on the nature and extent of the relaxation zone surrounding the longwall to be made when using local geomechanical, geological and mining input data.

Such a model has been developed and evaluated at Lunagas Pty Limited, Newcastle, Australia, under the name of 'Floorgas and Roofgas Geomechanical and Gas Release Models', and has been commercialised to operate on a Windows based platform.

Outputs from both programs (Figs. 1, 2 and 3) are used to design gas capture technologies, including cross measure or directional holes drilled from underground, and gas wells drilled from the surface. They are also used for precise gas make predictions and assessment of gas conditions necessary for planning gas management strategies.

Gassiness predictions based on the 'Floorgas' and 'Roofgas' models were compared with underground gas measurements from high production longwalls in Australia and other countries between 1992 and 1997. The results are sound, indicating accurate predictions of 90 to 95% efficiency, if the appropriate input data are available.

## 'FLOORGAS' AND 'ROOFGAS'

The programs can be used as engineering tools in the underground mining areas for:

1. prediction of gas emissions to the underground workings,
2. design of gas drainage holes and gas capture strategies,

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3. ventilation planning in underground coal mines,
4. planning for strata control,
5. definition of shearing zones and vertical loads, and
6. planning for coalbed methane utilisation and environmental control. (Lunarzewski, 1992; Lunarzewski et.al., 1995).

When using the "Floorgas" and "Roofgas" programs, the following benefits are achievable:

1. Identification of gas discharge and shear zone positions in the floor, strata relaxation angles and various gas discharge zones position in the roof, which are both relevant to local geological and mining conditions.
2. Calculation and definition of prediction coefficients such as specific gas emission and the relationships between gas beration, longwall width, and coal production levels.
3. Optimisation of cross-measure drainage hole length, location, number, and angles of deviation and inclination.
4. Optimisation of in seam drainage hole locations, the number and direction.
5. Assessment of active gas resources and their contribution in the pollution emission process.

The programs generate graphical outputs typified in Figs. 1, 2 and 3, depicting vertical cross-sections of longwall strata at various selected distances ahead of and behind the longwall face. 'Floorgas' output displays extend down to 100m below the working seam, while a 'Roofgas' output can show strata relaxation up to 200m above the working seam.

The 'Floorgas' program generates a vertical load distribution function along the chain-pillar and adjacent longwall panels/goaf areas. On the basis of the generated load, the program calculates vertical and shear stresses for each cubic metre of rock element being modelled. The program is a product of long-term detailed analyses and it uses results gained from various coal mines world-wide, with particular reference to mining and geological conditions in coal mines with daily productions greater than 5000 tonnes per longwall.

'Roofgas' calculates the position and shape of five gas release zones, with various degassing intensities, using the Lunagas empirical model (Lunarzewski, 1992). Then boundaries are quantitatively defined both in terms of discontinuous deformation of rocks and gas release percentages.

## INPUT DATA

Input Data is assembled from three (3) defined sources.

1. Geomechanical in which
  - Mechanical properties of the roof strata are expressed as
  - uniaxial compressive strength (UCS) values and
  - Strata stresses expressed as horizontal and vertical stress magnitudes, horizontal to vertical stress ratio, and horizontal stress direction related to longwall axis position.

2. Lithological - A geological (lithological) description and/or sonic velocity log of the strata for 'Floorgas'(100m below the seam), and 'Roofgas' (100m or 200m above the working seam).
3. *Mining and Gas*
  - a. Longwall block and pillar geometry;
  - b. Longwall advance rate or coal production level;
  - c. Coal seam positions in the strata; and
  - d. Gas flow or emission characteristics, if available.

## **OUTPUT PRINTOUTS**

Both programs generate scaled colour outputs on the basis of local geological, geomechanical, and mining data, in relation to longwall face position (Figs. 1, 2 and 3).

'Floorgas' printouts (Fig. 1) are prepared for one-half of the longwall face width, and show vertical cross-sections through the strata parallel to the longwall face, down to 100m below the seam. Both normal and shear stresses are calculated for each point within the dimensions of the model and are represented by a colour scheme defined in the legend. Printouts show strata relaxation and gas emission variations for nominated distances behind and ahead of a longwall face with reference to either a start line or drainage hole position. Every printout shows strata relaxation and gas emission zone shapes corresponding to the relative level of vertical stresses expressed in megapascals (MPa). Optional maingate and tailgate views are possible and each represents only one-half of the longwall width, with the other half regarded as symmetrical.

'Roofgas' printouts (Figs. 2 and 3) are prepared for one-half or full scale of the longwall face width. They show vertical cross sections through the strata parallel to the longwall face up to 200m above the seam. The printouts are prepared for nominated distances behind the longwall face with reference to a start line or drainage hole position. Every printout shows strata relaxation and gas emission zone shapes corresponding to the relaxation range and percentage of gas release, based on the Kidybinski Sequential Bed Separation Principle (Kidybinski, 1990), and Lunagas' empirical gassiness prediction model (Lunarzewski, L, 1992).

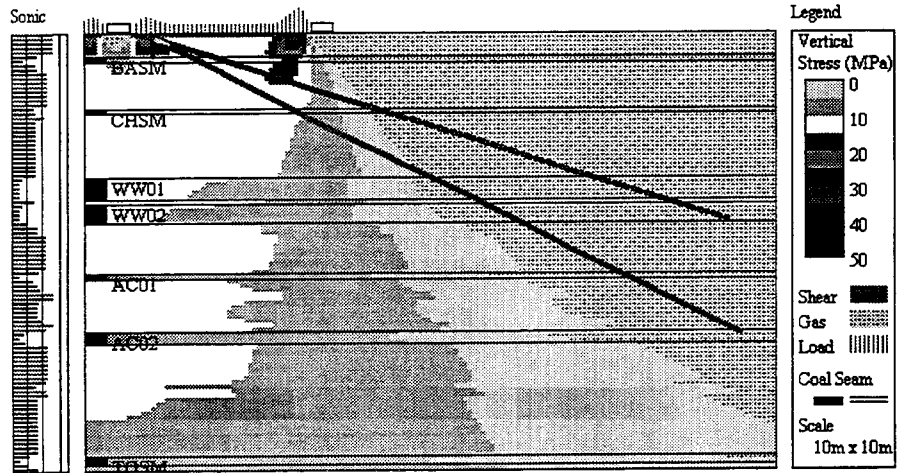
## **DRAINAGE HOLE DESIGN**

The program can be used most specifically for the precise design of underground drainage holes and surface gas wells, as well as identifying the strata relaxation, gas release, and shearing zones (Figs. 1, 2 and 3). Cross-measure hole positions in relation to the above mentioned zones, drilled and planned lengths, deviation and inclination angles can be applied directly to the printouts on the screen by use of the drainage hole tool. The user can draw an image of the hole on the cross-section, allow for changing hole positions, while the program simultaneously displays parameters according to the varying position. In seam hole positions in relation to the above mentioned zones, planned numbers and lengths can also be defined and designed, using strata relaxation gas release zone characteristics from 'Floorgas and/or 'Roofgas' outputs.

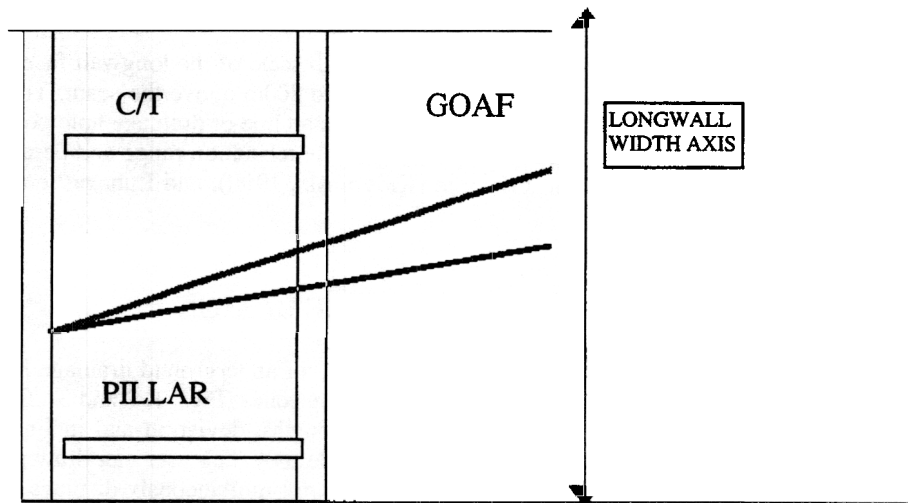
Accurate planning and optimisation of gas drainage holes may significantly increase the volume of captured gas, thus reducing the cost of drilling unsuccessful holes.

**FLOORGAS SIMULATION**  
**0m behind the face**

Tower\_LW15/1, Maingate 15/1 (205m x 1000m)  
 Bore: S1295



(a) Transverse Section

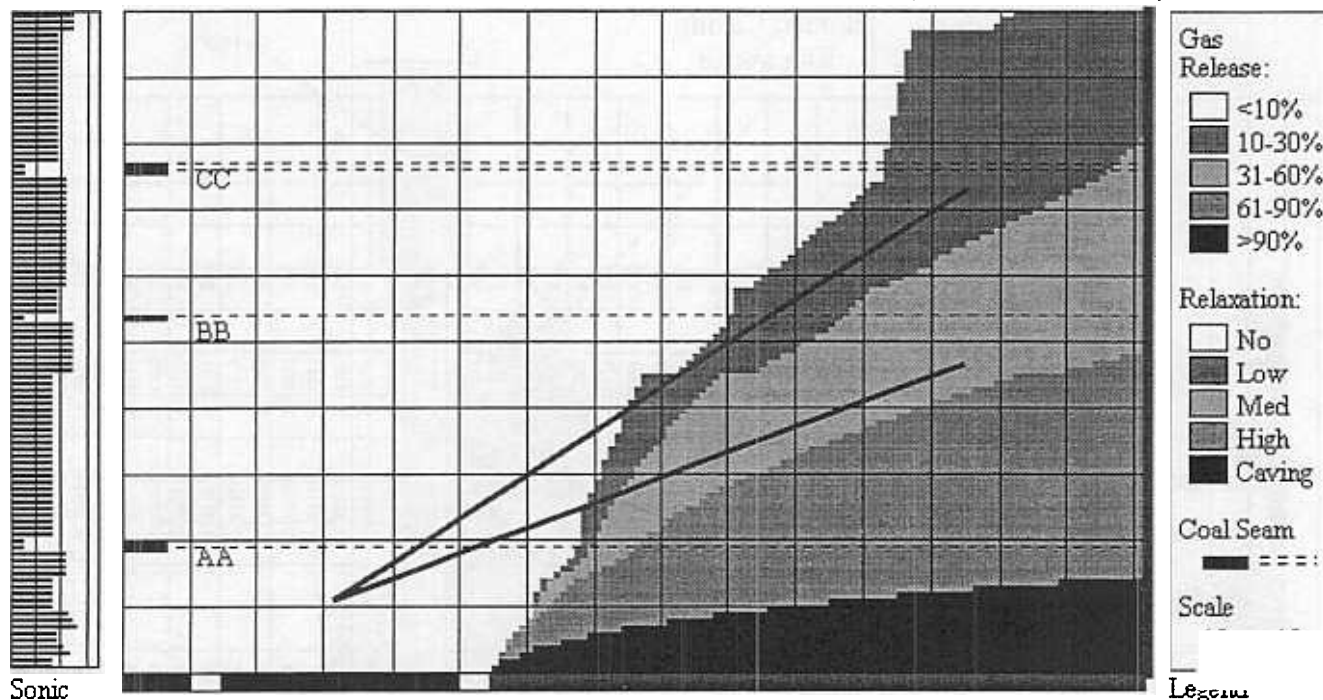


(b) Plan

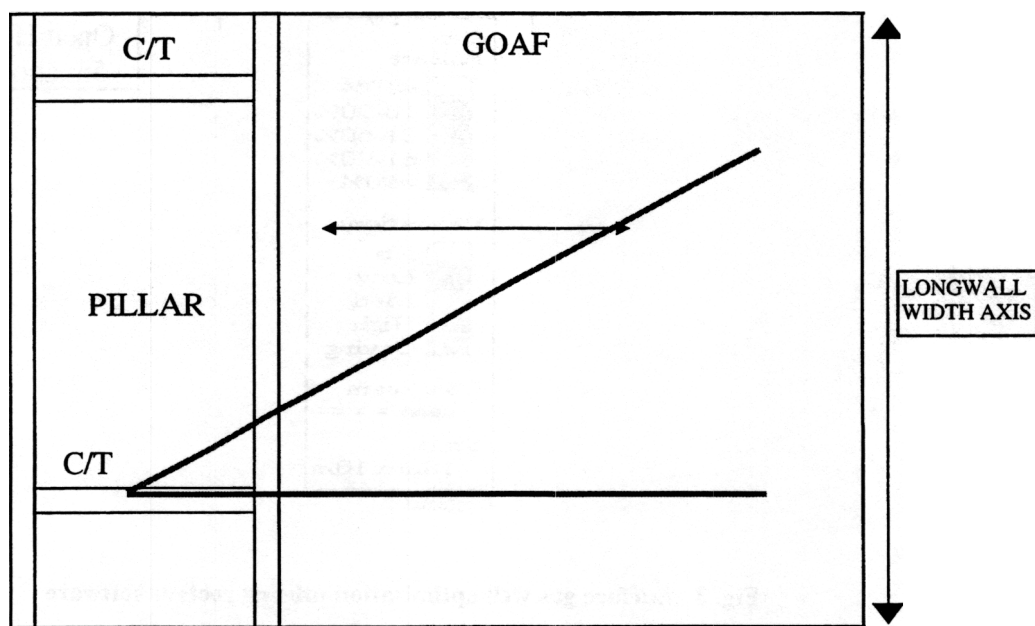
**Fig.1 – Floorgas simulated output, 0m behind the face**

**ROOFGAS SIMULATION**  
**300m behind the face**

Colliery: XXX  
 LW/Panel: LW XX (200m x 1500m)



(a) Traverse Section



(b) Plan

Fig. 2 - Roofgas simulated output, 300m behind the face

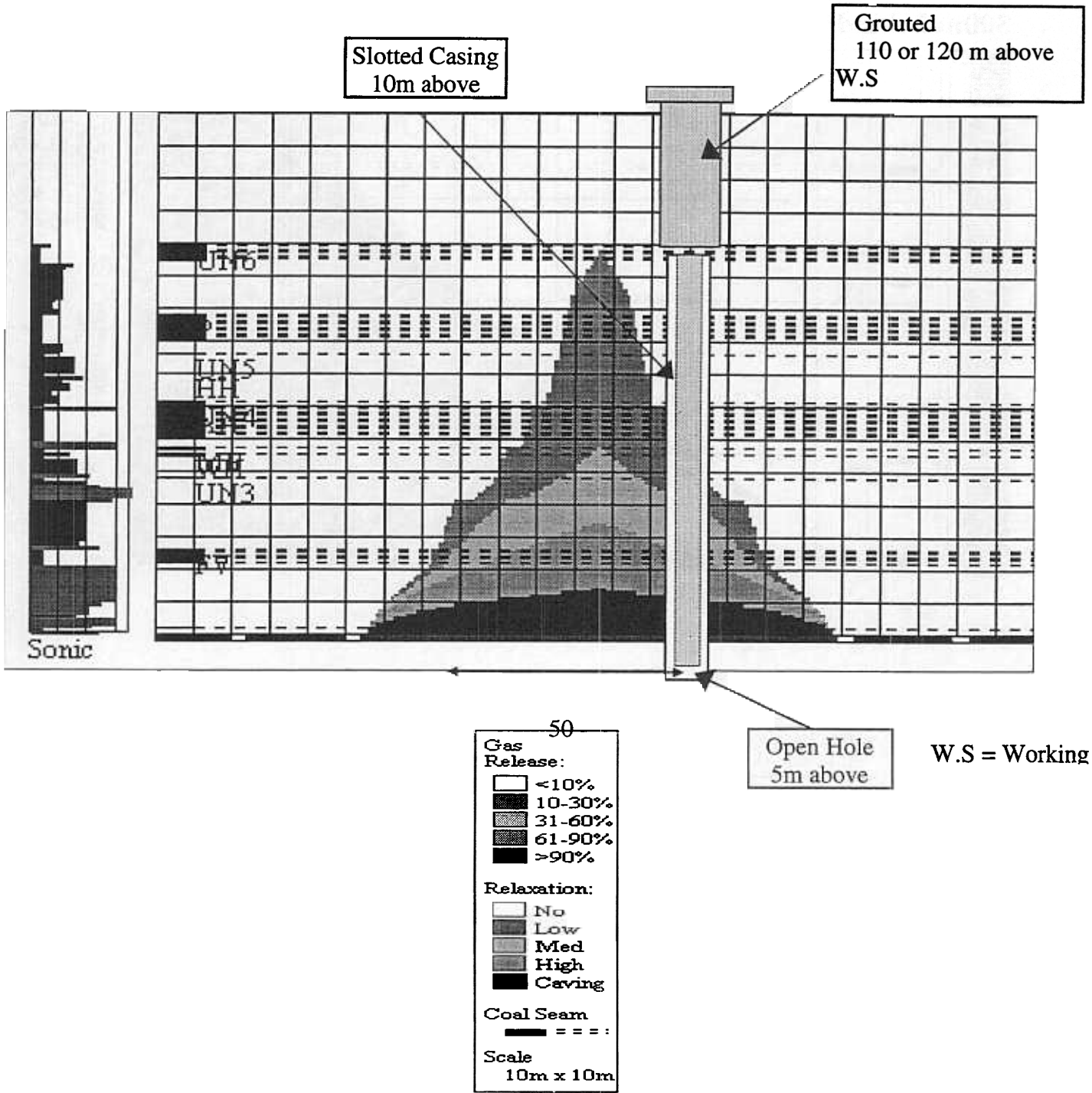


Fig. 3 - Surface gas well optimisation utilising roofgas software

## COMPUTER SOFTWARE AND HARDWARE REQUIREMENTS

The programs are written for a Microsoft Windows system and can be run with only the following minimum requirements: 486 IBM PC (or compatible), 8 megabytes of RAM, and Microsoft Windows operating system version 3.1 or later. 'Floorgas' and 'Roofgas' incorporate a graphical interface that assures easy and efficient data input, clear and concise outputs and design tools that improve accuracy and accelerate the design process.

An on-line help function includes all information on how to run the program, and gives examples and explanations of how to use the software for engineering purposes.

## CONCLUSION

The 'Floorgas and Roofgas Geomechanical and Gas Release Models' define the relationship between coal mining activities, strata relaxation and gas release-emission phenomena. Both programs are the most advanced engineering numerical tools available which improve the accuracy and quality of gas control, gas drainage, and ventilation systems design, as well as assess environmental air polluting emission rates from underground coal mines.

'Floorgas' combines a precise rock mechanics analysis with gas conditions to calculate stress and gas release zones in the floor strata of a working coal seam. 'Roofgas' can generate a roof strata break-line as a boundary between continuous and discontinuous rock masses. All methods published hitherto deal with continuous or discontinuous rocks separately with no possibility of indicating the boundaries between the two zones.

Gas control strategies including gas management planning, ventilation and gas capture system requirements can be defined and designed for specific local conditions, when utilising 'Floorgas' and 'Roofgas'.

Any world renowned gas drainage technology or practice can be optimised or programmed using outputs and results from 'Floorgas and Roofgas Geomechanical and Gas Release Models'.

## REFERENCES

- Dunmore, R, 1979, *Towards a method of prediction of firedamp mission for British coal mines* Proceedings, Second International Mine Ventilation Congress, Reno, USA, Nov 1979.
- Kidybinski, A, *Role of geomechanical modelling in developing new technologies in mines*. 14th World Mining Congress, Beijing (China), 1990, Proceedings - Vol.1, p. 549-555, IAP Editors.
- Lunarzewski,L, 1992, *Gas prediction, recovery, control and utilisation applicable to the mining industry*, Proceedings, Recovery and End-Use of Coalbed Methane, Katowice, Poland, March 16-21 1992, Report No.B1.
- Lunarzewski,L, 1992, *The role of predicted and measured gas emission in coal mine gas control*, Proceedings, International Symposium on Coalbed Methane Research and Development in Australia, Townsville, Australia, November 19-21 1992, Vol 4, p.97-105.
- Lunarzewski,L, Lunarzewski,A and Pilcher,R, 1995, *A new approach to predict underground gassiness for design of gas capture and ventilation systems*. Proceedings, Seventh US Mine Ventilation Symposium, Lexington, US, 5-7 June 1995, p. 61-66.