The role of predicted and measured gas emission in coal mine gas control

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INTRODUCTION

Gas problems, largely gas outs, arose in the early days of coal mining around the world, leading to the development of various mining, ventilation, and gas drainage techniques. With deeper mining and new gassy areas being mined, gas problems have increased. This has lead to more research, such as the direct relationship between gassiness and coal production levels. Mining and gas drainage techniques have been designed to suit special local geological conditions, taking into account statutory ventilation requirements.

A single longwall face recently produced an average of 6,000 - 8,000 tonnes per day with a maximum production level of 26, 000 tonnes per day (McKensey, 1990). Insitu gas content of coal seams can reach as high as 25 cubic metres of methane per tonne of coal. When extracting very gassy seams, using the longwall caving system, the total quantity of gas released to the underground workings can be as high as 6 cubic metres of methane per second. To control this environment it is necessary to establish a direct relationship between predicted gassiness and planned coal production levels for development drivage and longwall extraction. This relationship can then be used to assess ventilation requirements and achievable coal production levels necessary to satisfy statutory limitations.

GAS EMISSION TO THE UNDERGROUND WORKINGS

The pressure difference between inseam pressure in gas sources and atmospheric pressure in relaxed strata/underground workings causes sorbed gas in the gas sources' coaly material to become free gas. This free gas then flows through the strata's cracks and fissures towards the goaf areas, underground workings/ventilation network, and/or migrates to the surface.

During the process of mining (shaft sinking, development drivage, longwall and/or pillar extraction) various quantities of gas are emitted to the underground workings from the working seam and other gas sources in the roof and floor strata.

DEFINITIONS

Gas emission can be expressed in three basic units defined as follows:

Specific gas emission

- is the predicted quantity of gas which is expected to be released to the underground workings from all gas sources as a result of coal production during the extraction of one tonne of coal.

Absolute gassiness

- is the measured quantity of gas expressed in cubic metres or litres emitted to the underground workings and/or to the atmosphere during a defined period of time (second, minute, hour, day, ..., year).

Relative gassiness

- is the measured quantity of gas expressed in cubic metres and related to the associated coal production levels achieved during various periods of time.

SPECIFIC GAS EMISSION - GASSINESS PREDICTION

Specific gas emission is the final result of selected calculations used in various methods of gassiness prediction. Currently available techniques for the prediction of gassiness have been developed by research organisations and individual investigators world wide, relevant to local mining, geological, and gassy conditions and their own experiences.

Most methods adopt the same basic parameters:

- the stratigraphy and lithology above and below the worked seam;
- the insitu gas content of the worked and adjacent seams and gas bearing rocks;
- the strata relaxation zones;
- the degree of gas emission from roof and floor gas sources.

However, the accuracy of the prediction depends substantially on specific co-efficients established for local mining and geological conditions.

Geological factors and stratigraphy

A strong direct relationship exists between the gas emission rate and the geological factors, in association with longwall extraction. The stratigraphical section above and below the worked seam is of great importance when using longwall systems with total caving. A considerable proportion of methane entering the underground workings originates from surrounding coal seams and gas bearing sources. The number, position, and total thickness of adjacent coal seams are of vital significance.

Insitu gas content

An accurate value of the insitu gas content of worked and adjacent coal seams is of prime importance for any gas prediction technique. For unassessed areas, the combination of indirect and direct methods of determining the insitu gas content is recommended in order to establish insitu gas content and pressure, and sorption isotherms of the coal. In some instances the direct method is sufficient which involves the direct sampling of coal from exploration boreholes or fresh coal face underground. This is followed by measurements of initial desorption, both in the field and the laboratory, as well as applying the appropriate crushing technique to obtain quick measurements of the remaining gas.

Degree of gas emission from the roof and floor - relaxed zones simulation

Relaxation of roof and floor strata allows gas to flow from adjacent gas sources to the goaf areas and underground workings. The intensity of the gas flow depends on the type and strength of the rocks and the degree of strata relaxation. For this reason accurate borehole logs, and/or sonic velocities, are essential for the application in gassiness prediction models. Such models (computer simulation programs) have been developed for longwall floor and roof gas sources.

Boundary element and sequential bed separation methods, developed and managed in Europe for floor strata relaxation and immediate roof bedding separation (Kidybinski, 1991), have been utilised for defining relaxed/caved zones. These methods assess caving, strata relaxation, shear and gas emission zones and their ratios for gas emission prediction and design of cross-measure holes in the floor and/or roof strata.

These methods have been modified and utilised by Lunagas Pty Limited under the names of "FLOORGAS" and "ROOFGAS" simulation programs. The programs calculate stresses in rock/coal seams using boundary element and/or sequential bed separation approaches, and superimposes tectonic (horizontal) stress components if they are known. Finally, the programs generate maximum shear criterion to find the shape of the sheared zone, and define "gas discharge stress criterion" to calculate gas release zones and their ratios. Relaxed zones show the percentage contribution to gas emission taking into account stratigraphy, vertical and horizontal stresses, coal/rock properties and distances from the worked seam. Careful selection of these zones is essential.

Each local environment will have to develop its own gas emission zones, and their ratios, depending upon geology, strata stresses, mining, and gas conditions (Lunarzewski, 1992).

Figures 1 and 2 show examples of simulated zones for floor and roof gas sources, analysed in relation to drainage hole location, when the longwall face has moved 100 metres passed the gas drainage hole. Similar results can be prepared for various face distances along the longwall block.

A reasonably accurate prediction of gassiness can be made, using world wide methods, when mining in situations of homogeneous stratigraphy, provided sufficient geological, mining, and gas data are made available. However, much better results can be achieved when using "FLOORGAS" or "ROOFGAS" simulation programs with specific local input data.

Figure 3 shows a flow chart of longwall total gas emission prediction. Various assumptions are analysed together with a comprehensive study of the local mining and geological environment, to form a model which is adaptable to any local conditions.

Total gas emission is calculated using the following coefficients:

- strata relaxation zones and their gas release ratios;
- degree of gas emission from the working seam;
- daily and weekly coal output.

The coefficients, which have been empirically developed for high production longwall levels achieved in Australia, are unique for locally defined conditions, longwall face width of 100 - 200m, and daily coal production of 10,000 tonnes. The accuracy of the above gassiness prediction method is within 10 to 15%, as shown in Figure 4.

ABSOLUTE GASSINESS (litres CH_4/second)

Absolute gassiness is a true reflection of underground gassiness conditions in terms of total quantity of gas released from the strata during a specific period of time. Total measured gas make is a combination of the following:

- gas emission rate into the underground ventilation system;
- gas emission rate into the underground and/or surface gas drainage system.

Absolute gassiness is the only condition which can be practically utilised as an expression of a collierys gassiness in determining the appropriate ventilation requirements necessary to dilute gas emitted into the ventilation system to the statutory limits. Absolute gassiness can also be related to periods of longwall extraction/development drivage in terms of face location or time. Figure 5 shows typical changes in absolute gassiness associated with longwall extraction distances and daily coal production levels.

RELATIVE GASSINESS (m^3CH_4/tonne)

Relative gassiness reflects the relationship of absolute gassiness with coal production levels over a specific period of time. Relative gassiness must always be qualified when expressed with its associated period of time and in terms of mining activities and areas of influence (e.g. longwall or pillar extraction, development drivage, colliery districts and leases).

Relative gassiness can only be utilised as an expression of underground gassiness if consistent mining conditions and coal production levels are maintained over significant time periods. The period of time for longwall extraction with caving, has been found to be a minimum of two weeks.

Figure 6 shows the relative gassiness in m^3CH_4/tonne (figures on the top of bar-graphs) during a typical longwall production cycle for three selected periods of time:

- daily;
- weekly;
- monthly.

The daily graph shows that relative gassiness varies from 7 to 169 m^3CH_4/tonne depending on daily coal production levels. During idle periods (weekends) relative gassiness was infinity. The high range of variations suggest that longwall relative gassiness on a daily basis is not appropriate for expressing underground gassiness conditions.

The weekly graph shows a range of 13 to 49 m^3CH_4/tonne, however, some periods do show consistent values when coal production levels were stable (weeks 31 to 34, 35 to 36, 39 to 40, and 45 to 47).

The monthly graph shows a range of 12 to 33 m^3CH_4/tonne with variations due mainly to changes in mining conditions rather than coal production variations.

The range of relative gassiness variation diminishes as time periods are extended.

If coal production levels are consistent for two weeks or more then relative gassiness also is consistent and is similar to the specific gas emission calculated and predicted for these conditions.

Figure 7 shows the relative gassiness during a typical production cycle and through drivage of the development panel. The graph shows that relative gassiness varies from 5 to 205 m^3CH_4/tonne depending on gas balance measurement periods and total tonnage extracted in that time. During idle periods (weekends) relative gassiness was infinity. The high range of variations suggests that development relative gassiness should not be expressed relative to time but relative to advance rate.

CONCLUSIONS

- Specific gas emission is the predicted quantity of gas which is expected to be released into the underground workings from all gas sources as a result of extraction of one tonne of coal.
- A reasonably accurate prediction of gassiness can be made, using specific gas emission calculations, provided sufficient geological, mining, and gas data are made available.
- Boundary element methods and sequential bed separation methods have been utilised to develop new gas emission simulation programs for specific gas emission and longwall gassiness prediction.
- Absolute gassiness is the only condition which can be practically utilised as an expression of colliery gassiness in determining the appropriate ventilation requirements.
- Relative gassiness must always be qualified when expressed with its associated period of time and in terms of selected mining activities and areas of influence.

REFERENCES

McKensey, B. An overview of mechanised longwalls in Australian mines. 1990 International Coal Engineering Conference, Sydney, Australia, 19 - 21 June 1990.

Kidybinski, A. Personal communications. November 1991 and March 1992.

Lunarzewski, L. Gas prediction, recovery, control and utilisation applicable to the Mining Industry. International workshop on the Recovery and End-use of Coalbed Methane, Katowice, Poland, March 1992.

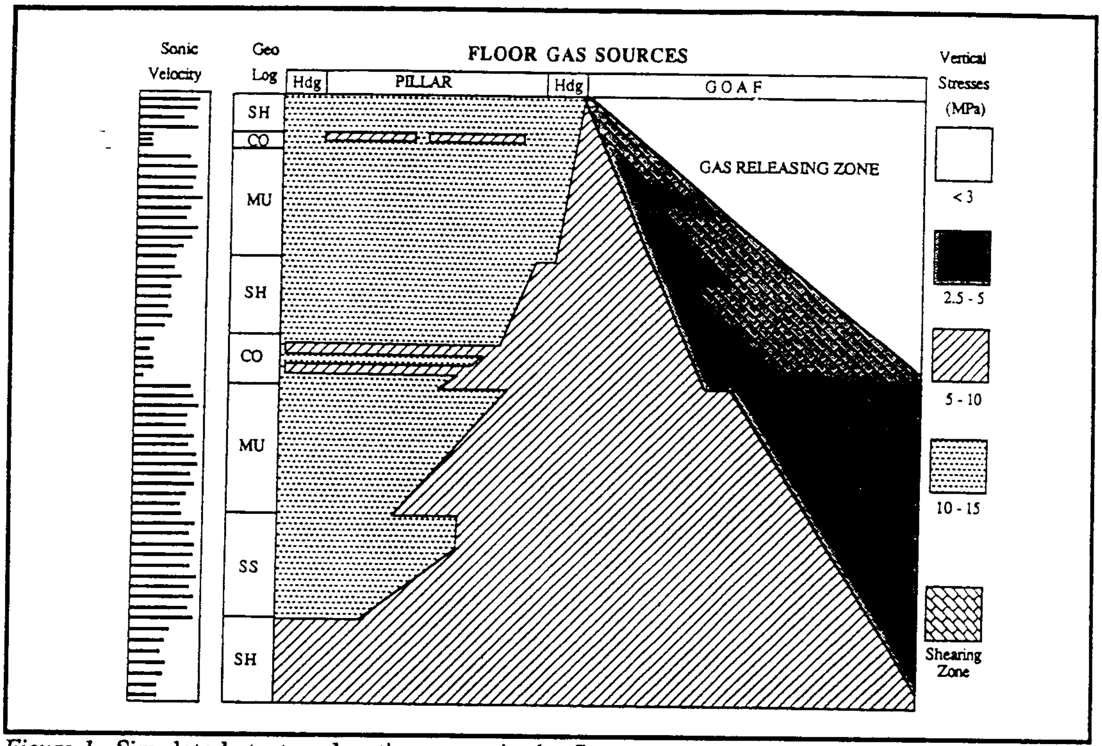

Figure 1. Simulated strata relaxation zones in the floor

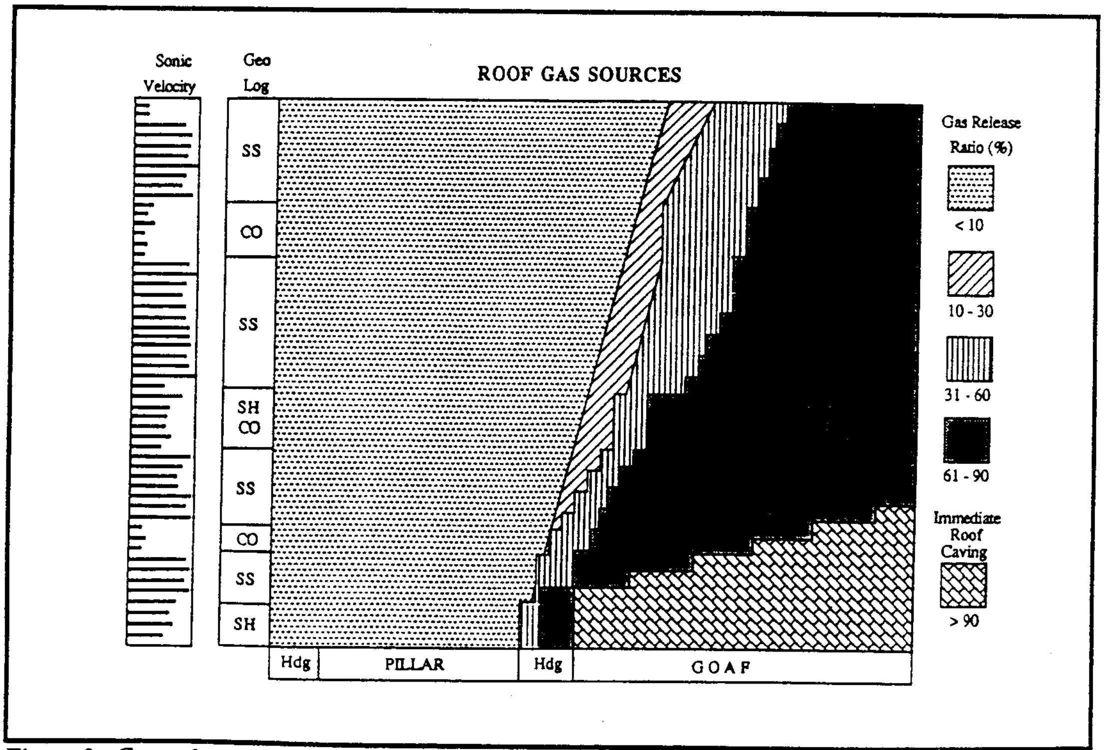

Figure 2. Gas release zones, and their ratios, in the roof

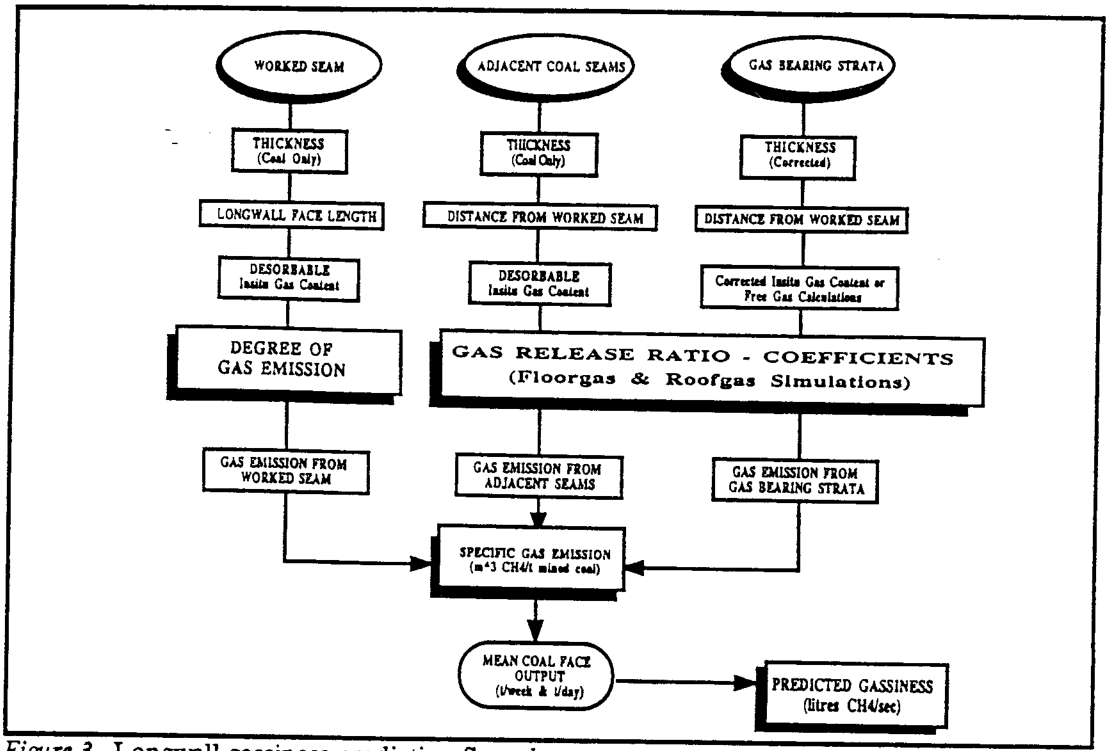

Figure 3. Longwall gassiness prediction flow chart

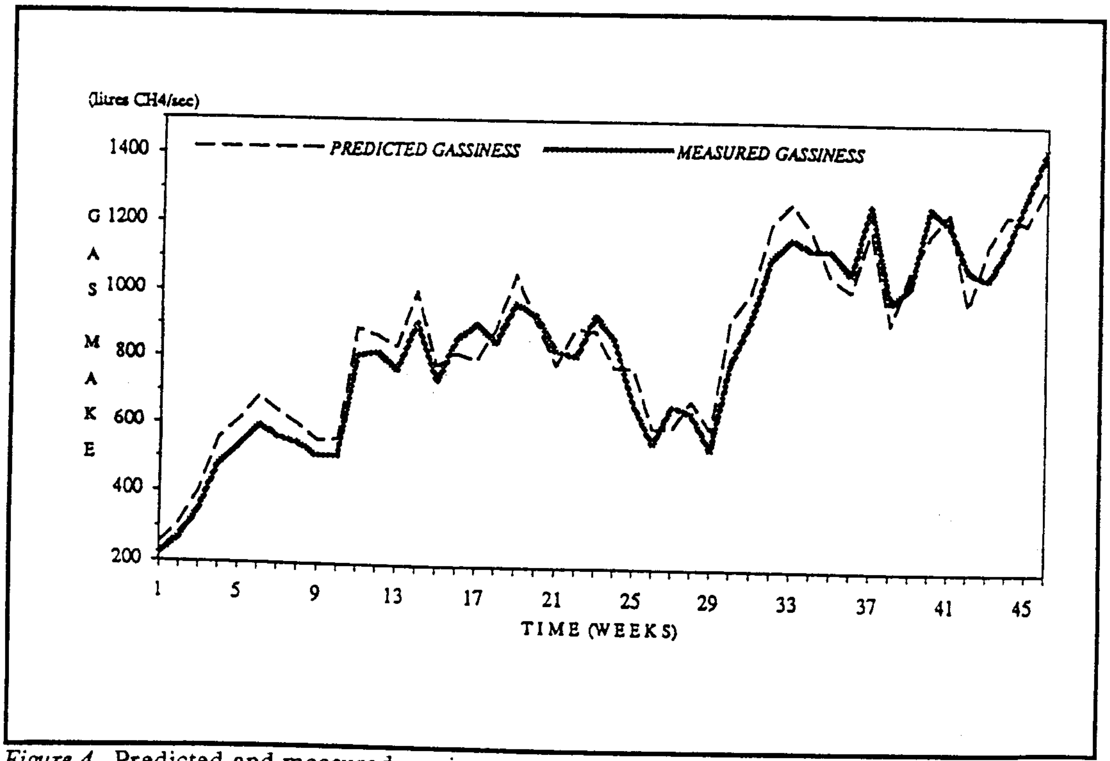

Figure 4. Predicted and measured gassiness comparison

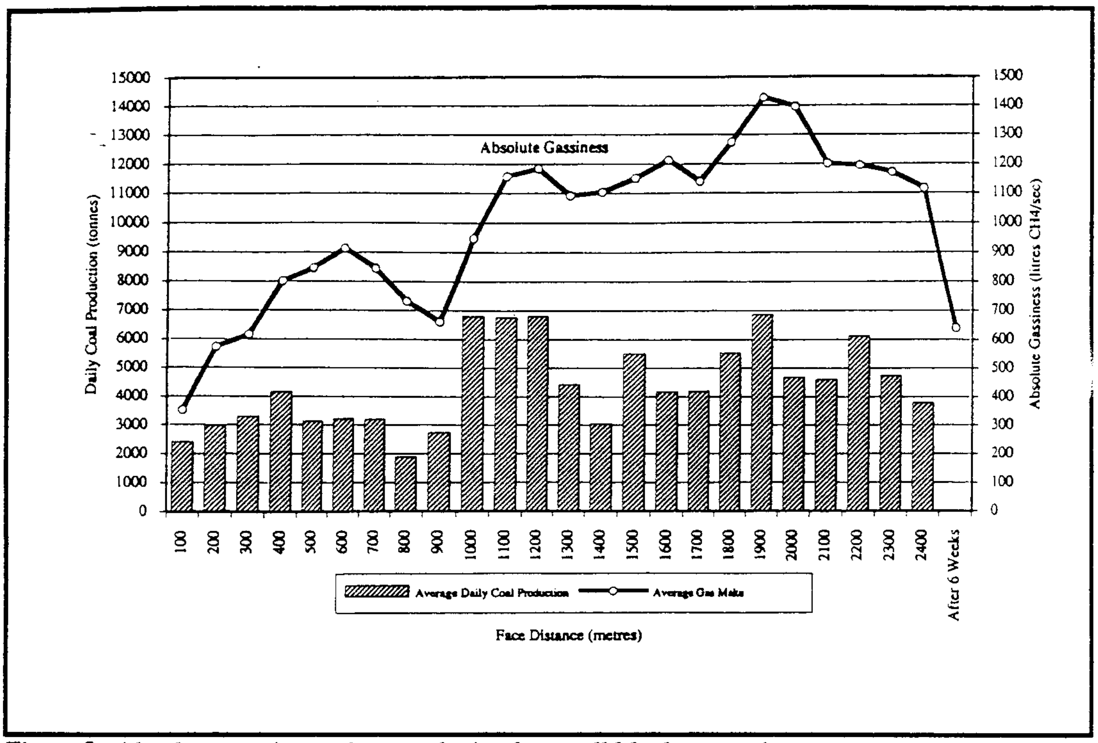

Figure 5. Absolute gassiness changes during longwall block extraction

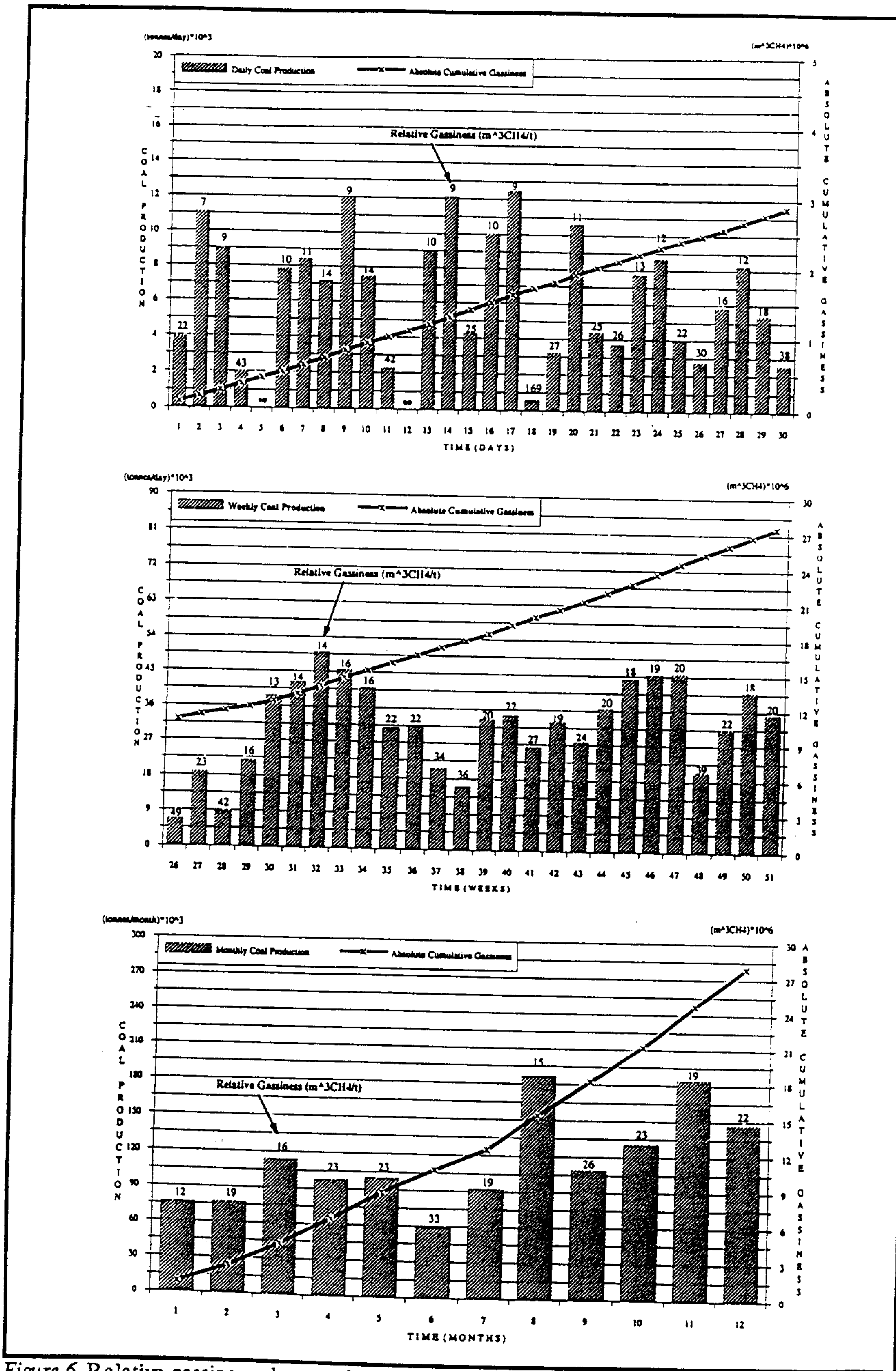

Figure 6. Relative gassiness changes during longwall extraction

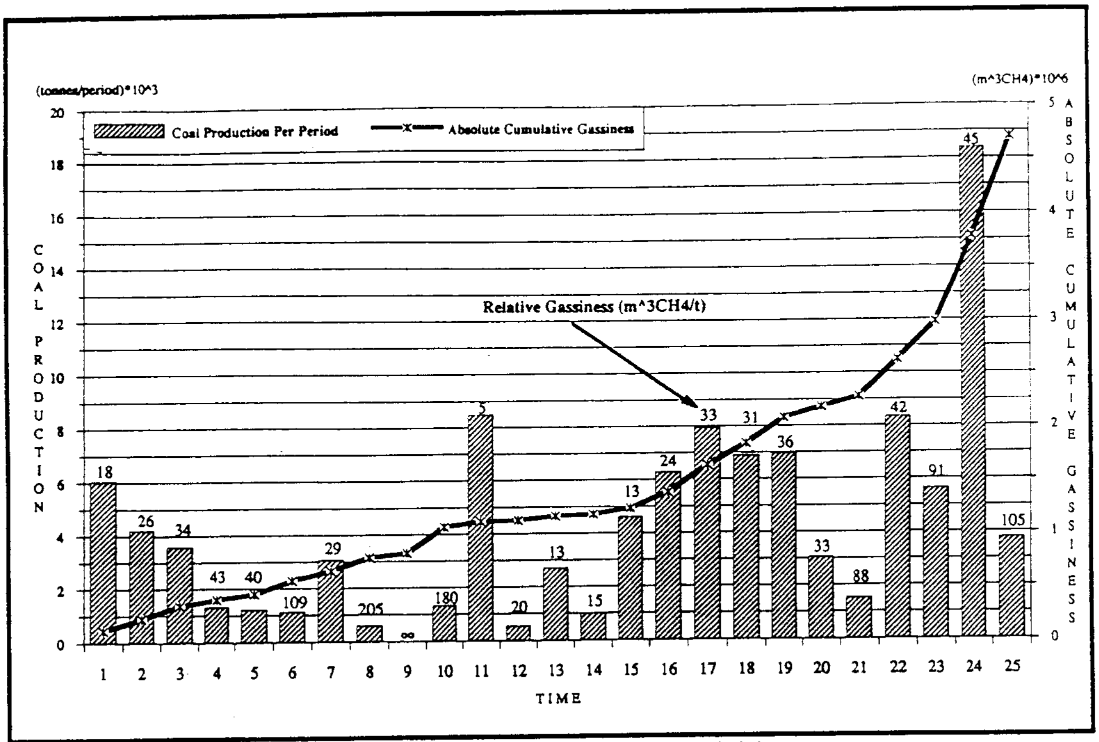

Figure 7. Relative gassiness changes during development panel drivage