Modelling of the Occurrence of Hydrogen Sulphide in Coal Seams

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ABSTRACT

Hydrogen Sulphide (H_2S) has been encountered within a number of Bowen Basin collieries, Central Queensland, Australia. High concentration occurrence during mining of a longwall panel raises a number of potential problems, which demand greater understanding to allow efficient mining while maintaining safe and healthy environmental conditions. Longwall panels at Mine A and Mine B have recently mined through H_2S zones. The high H_2S zone mined through at Mine A was wide and covering the whole length of the face comparing to the narrow H_2S zone which was cutting the panel at 45° at Mine B. Longwall panels had been sampled for H_2S in pre-mining phases with vertical and inseam exploration boreholes and rib sampling of gateroad development headings. During mining face coal samples were collected in an intensive program and tested in a drum tumbler to determine an "indicated" seam concentration level through contouring that could be used to calculate the concentrations of H_2S liberated to the atmosphere. Data was analysed to determine a geostatistical method, which would best represent the "indicated" seam concentration level from the given data and the block dimension of the data set. This study discusses the different sampling methods used, selection of the most suitable geostatistical method and the impact of grid size on results of data analysis. Some general observations are made correlating "indicated" seam H_2S concentrations from production face sampling with both predictions made from exploration and liberation rates during mining of the longwall panel.

KEYWORDS

Hydrogen Sulphide, H_2S, Seam Gases, Mine Ventilation, and Geostatistical Methods.

INTRODUCTION

The occurrence of significant quantities of Hydrogen Sulphide (H_2S) in coal seam gases is rare around the world. H_2S has been recorded as occurring in coal seams in France, Canada, China, Russia and Australia. In Australia significant occurrences have been found in a number of mines in Queensland (Ryan, *et al.*, 1998; Harvey, *et al.*, 1998). Mines A and B are underground longwall operations mining the German Creek seam, the lower major economic seam of the Bowen Basin's Permian German Creek formation (Ko Ko and Ward, 1996).

A research project examining the occurrence of H_2S coal seam gas jointly funded by the Australian Coal Association Research Programme and Queensland's Mines A and Mine B has been undertaken with principal aims to investigate:

- Occurrence of H_2S,
- Prediction of H_2S release,
- Storage mechanisms,
- Mine ventilation system and control measurements,
- Mining options,
- Permeability, and
- In seam chemical neutralisation.

The project has been staffed by a research team from the University of Queensland's Departments of Mining, Minerals and Materials Engineering, Earth Sciences and Chemistry (Gillies, *et al*, 1997). This paper examines one of these areas, namely prediction of H_2S release. It focuses on some aspects of sampling and geostatistical analysis undertaken while modelling the distribution of H_2S seam gas within the coal seams at Mine A and Mine B.

Longwall panels at Mine A and Mine B have mined through a number of H_2S zones intersected by longwall panels since late 1996. The high H_2S zone mined through at Mine A was wide and covering the whole length of the face comparing to the narrow H_2S zone which was cutting the panel at 45° at Mine B. Longwall panels had been sampled for H_2S in pre-mining phases with vertical and inseam exploration boreholes and rib sampling of gateroad development headings.

During mining face coal samples were collected in an intensive program and tested in a drum tumbler to determine an "indicated" seam concentration level through contouring that could be used to calculate the concentrations of H_2S liberated to the atmosphere. Data was analysed to determine a geostatistical method, which would best represent the "indicated" seam concentration level from the given data and the block dimension of the data set.

This study discusses the different sampling methods used, selection of the most suitable geostatistical method and the impact of grid size on results of data analysis. Some general observations are made correlating "indicated" seam H_2S concentrations from production face sampling with predictions made from exploration and with liberation rates during mining of the longwall panel.

GENERAL INFORMATION ON H_2S

Properties of H_2S

H_2S, which is also known as sulphuretted hydrogen or rotten egg gas has no colour but a powerful and unpleasant odour. It is liquid at high pressure and low temperature. It has a specific gravity of 1.19 and burns in air with a bright blue flame producing sulphur dioxide and water vapour. The human nose can detect concentrations as low as 0.02 ppm, however increasing exposure desensitises the olfactory organ and concentration levels above 50 ppm can no longer be smelt. H_2S forms flammable mixtures in air in the range of 4.5-45 per cent. It is highly reactive and corrosive to all organic and metallic compounds.

Occurrence of H_2S

H_2S has been found in deposits of rock salt, sulphur, gypsum, lead, petroleum and natural gas. It is also present in the gases from many volcanoes, sulphur springs, undersea vents, swamps and stagnant bodies of water. Bacterial reduction of sulphates and bacterial decomposition of proteins form H_2S (Grayson and Eckroth, 1983). Large quantities of H_2S occur in natural gas deposits of France and Canada. The occurrence of fossil H_2S gas in coal measure strata has been noted in France, Canada, China, Russia and Australia (Ko Ko and Ward, 1996).

In a study by Smith and Philips (1990) on the sulphur isotope ratio $^{34}S/^{32}S$, the source of coal seam H_2S was proposed as a biological reduction of sulphate supplied from a marine transgression which was generated in a low iron environment and was not converted to pyrite. This allowed large quantities of H_2S to react with organic matter and to be trapped within the coal seam during the maturation. Moelle (1987) (cited Phillips, *et al.*, 1990) suggests that the occurrence of H_2S in Europe was associated with sapropelic muds containing the remains of the Carboniferous plants. Recent research into the sources of H_2S in coal at Mines A and B has given more weight to an organic rather than an inorganic source (Golding, *et al.*, 1998).

Physiological Effects of H_2S

H_2S is an extremely toxic gas and can cause death at exposures above 500 ppm. It irritates the lungs and respiratory tract and has a narcotic effect on the central nervous system (Strang and Mackenzie-Wood, 1990). The reaction of H_2S with fluids in the nose and lungs forms sulphuric acid. The toxicity of H_2S is due to the H_2S molecule itself rather than to Hydrosulphide or sulphur ions (Elvers, *et al.*, 1989).

The effect of H_2S on a person's health can be extreme, depending on the concentration to which they are exposed. The duration of exposure, while still important, is of secondary interest as indicated in Figure 2.

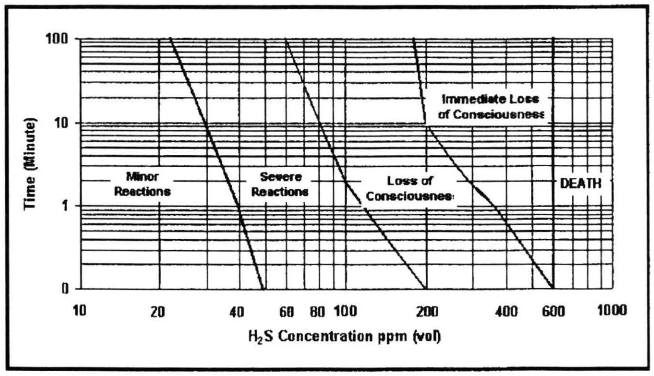


Figure 2. Effects of H_2S as a function of concentration and exposure time.

Threshold Limits of H_2S

The maximum allowable concentration of H_2S in the mine atmosphere permitted by the Queensland Coal Mining Act General Rules for Underground Coal Mines is 10 ppm (0.001%). This applies to any airway that workers may enter including belt roads and returns. The Australian Standard for exposure to H_2S is 10 ppm (TWA-8 hrs) or 15 ppm (STEL-15 min.). The United States Department of Labor, Occupational Safety and Health Administration's acceptable ceiling concentration is 20 ppm for 10 minutes once only if no other measurable exposure occurs. The acceptable maximum peak concentration above the acceptable ceiling concentration for an 8-hour shift is 50 ppm.

PREDICTION OF IN-SITU COAL H_2S GAS LIBERATION

Sampling

The prediction of in-situ coal H_2S gas liberation levels which will be released in the mining sequence during cutting, breakage and transport can be achieved by testing exploration cores or rib coal samples exposed during development.

Obtaining representative samples from coal containing H_2S is complex. H_2S is a difficult gas to contain as it is highly reactive and is able to permeate through most container walls. Each sample collected for testing must be sealed on site. For longer-term storage of samples Teflon containers or a plastic pipe capped at both ends (Figure 3) can be used.

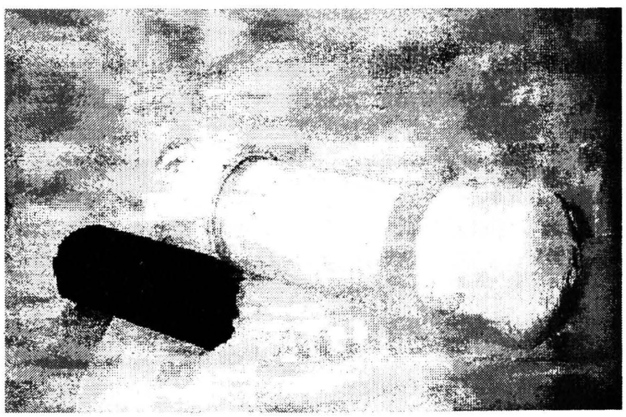


Figure 3. A core sample and plastic pipe container.

A number of different sampling and testing methods can be utilised during pre-mining to predict the levels of H_2S concentration in the gassy zones including rib sampling, vertical drilling and in-seam horizontal drilling core sampling methods (Gillies, *et al.,* 1998).

Rib Sampling Technique

One of the least costly methods of identifying and mapping an H_2S gas zones is to take channel samples from the rib sides of the gateroad headings when an H_2S zone is intersected during panel development. A number of rib samples can be taken along the development maingate and tailgate headings as seen in Figure 4. The rib samples should be taken from the middle of the rib sides using a handheld pneumatic chainsaw.

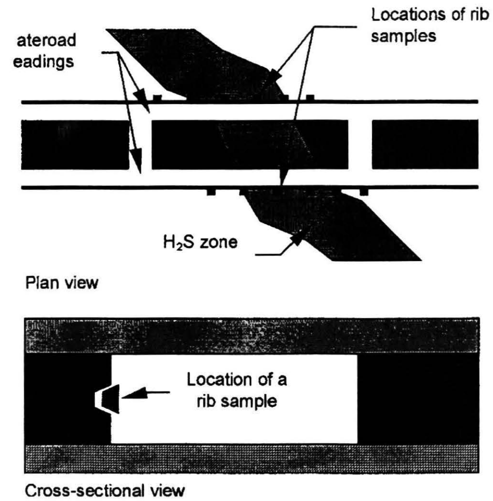


Figure 4. Rib sampling technique.

In-Seam Horizontal Drilling Technique

Rib sampling is a cost effective method for predicting the location and the extent of H_2S gas zones along the panel when intersected during development. However, this approach will normally not provide adequate details of the size and shape of the zone and on the concentration levels of the gas within the panel. One way of obtaining this information is through in-seam horizontal drilling.

After the H_2S zone is located on one or both sides of a panel, a horizontal drilling program can be carried out to determine the extent of the H_2S zone within that panel. During this program, core samples should be taken as frequently as budgets and testing procedures allow. The location of the horizontal holes and testing results can then be indicated on a plan view.

Vertical Drilling Technique

Another way of identifying the H_2S zones is through vertical drilling form the surface. Although it is easier to work on the surface than underground and heavier machinery can be used, a thick layer of rock must be penetrated before reaching the coal seam. Each hole intersects the seam only once and so more holes need to be drilled than with in-seam drilling to delineate the H_2S zone to reasonable precision.

EXAMINATION OF INDICATED H_2S GAS LIBERATION

During production mining close spaced sampling of the face can be undertaken to establish the indicated H_2S gas concentration profile within the zone. This allows correlation studies to be undertaken with results from pre-mining exploration prediction campaigns based on horizontal or vertical drilling and rib samples. It also allows comparison with gas release concentrations measured in the mine airflow ventilating the working face.

During face sampling campaigns seam samples are cleaved at mid height from the freshly exposed face at intervals of approximately 50 m or less along the face. They should be sealed from exposure to the atmosphere and taken from the mine for immediate analysis

DETERMINING H_2S CONTENT OF COAL

There was no established technique for determining H_2S content of coal when the contaminant was first encountered within Queensland's Bowen Basin. An early form of drum tumbler system was developed to determine the H_2S content of coal at Mine B (Phillips, *et al.,* 1990). A modified design with the ability to constantly sample gas during coal breakage was developed by O&B Scientific (see Figure 5) in 1996.

The system consists of a rotating high-density polyethylene 255-litre drum. The drum tumbles a sample at 20 rpm for approximately 180 seconds. The period of rotation is selected to produce coal breakage representative of the size of coal on the armoured face conveyor (AFC). The sample is sized after testing. The test is used to determine the volume of H_2S released into the atmosphere from a given sample under controlled conditions.

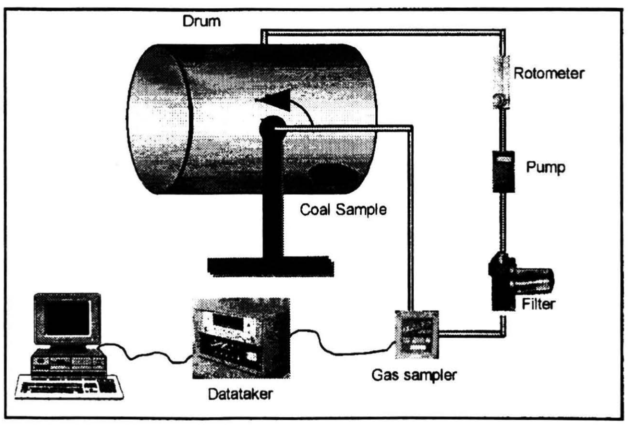


Figure 5. Drum tumbler system (Gillies and Kizil, 1997).

GEOSTATISTICAL ANALYSIS FOR H_2S DISTRIBUTION PREDICTION

There is a great deal of uncertainty associated with coal sample collection and testing for H_2S gas content. It was felt necessary to develop a reliable model for analysis of coal samples in order to be able to predict the H_2S concentration, which will be liberated from coal on the face during mining. The purpose of this analysis was to:

- Select the most suitable geostatistical method for modelling H_2S seam gas distribution from test results of coal samples (contour mapping).
- Determine the impact of grid size on results of data analysis.
- Provide further recommendations for geostatistical data analysis and sampling and testing procedures.

The package SURFER (Keckler, 1997) was used in this exercise. It incorporates a grid based contour program and makes use of original data points in an XYZ data file to generate calculated data points on a regularly spaced grid.

Geostatistical Methods

SURFER provides a large list of gridding methods and options. Different gridding methods can have different results when interpreting data files. It is not always easy to decide which gridding method is best. Eventually the best gridding method is the one, which produces the map that best represents the data as correlated through comparison with gas release during mining.

There are eight geostatistical methods (Figure 6) that can be used in the SURFER package. Out of these, Kriging (Gillies, *et al.,* 1997, Isaaks and Shrivastava, 1989; Wackernagel, 1995), appears to be the best choice for contour mapping. The other methods did not appear to give predictions derived from practical knowledge and experience.

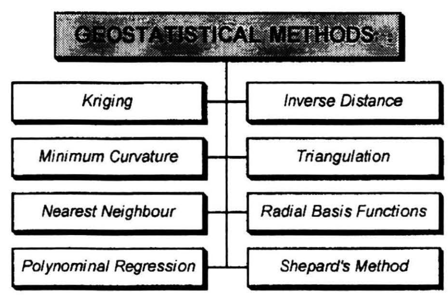


Figure 6. Geostatistical methods available for contouring within SURFER package.

Kriging

Kriging is one of the more flexible geostatistical methods and is useful for gridding many types of data sets. There are several factors of importance in the Kriging method: Variogram Model, the Drift Type, Nugget Effect and Anisotropy.

Variogram Model: The variogram is used to determine the local neighbourhood of observations used when interpolating each grid node and how the weights are applied to the observations during the grid node calculation. There are several variogram models including Linear, Exponential, Gaussian, Hole Effect, Quadratic, Rational Quadratic and Spherical.

Drift Type: It has a significant effect during gridding when interpolating across large hole spacing in the data distribution pattern and when extrapolating beyond the limits of the data.

Nugget Effect: It is used when there are potential errors in the collection of the data. The nugget effect is implied from the variogram generated from the data. Specifying a nugget effect causes Kriging to become more of a smoothing interpolator, implying less confidence in individual data points versus the overall trend of the data. The higher the Nugget Effect, the smoother the resulting grid.

Anisotropy: This option introduces different weighting factors along different geometric axes. When more significance wants to be applied to data points along a particular axis, an anisotropy ratio can be introduced. Ratio value is increased to impart higher relative weighting along a particular axis. Anisotropy axes can also be oriented at any angle by defining the angle value.

Inverse Distance to a Power

The Inverse Distance to a Power gridding method is a weighted average interpolator. The Power parameter controls how the weighting factors drop off as distance from a grid node increases. For a larger power, closer data points are given a higher fraction of the overall weight; for a smaller power, the weights are more evenly distributed among the data points.

One of the characteristics of inverse distance is the generation of "bull's-eyes" surrounding the position of observations within the gridded area. A smoothing parameter can be used to reduce the "bull's-eye" effect by smoothing the interpolated grid. It also allows incorporation of an uncertainty factor associated with input data.

Minimum Curvature. Minimum Curvature is a common geostatistical method used in the earth sciences. The interpolated surface generated by Minimum Curvature is analogous to a thin, linearly elastic plate passing through each of the data values with a minimum amount of bending. Minimum Curvature generates the smoothest possible surface while attempting to honour data as closely as possible. It is not an exact interpolator however.

Radial Basis Functions. Radial Basis Functions are a diverse group of data interpolation methods. The Radial Basis Function methods are exact interpolators that make an attempt to honour the input data. A smoothing factor can be introduced to all the methods in an attempt to produce a smoother surface. The functions define the optimal set of weights to apply to the data points when interpolating a grid node.

Shepard's Method. Shepard's Method uses an inverse distance weighted least squares method. As such it is similar to the Inverse Distance to a Power interpolator but the use of local least squares eliminates or reduces the "bull's eye" appearance of the generated contours. Shepard's Method can be either an exact or a smoothing interpolator.

Nearest Neighbour. Nearest Neighbour is useful for converting regularly spaced XYZ data files to SURFER grid files. When the data set forms a nearly complete grid with only some missing holes, this method is useful for filling in the holes, or creating a grid file with the blanking value assigned to those locations where no data is present.

Polynomial Regression. Polynomial Regression processes the data so that underlying large-scale trends and patterns are shown. This is used for trend surface analysis. It is very fast for any amount of data, but local details in the data are lost in the generated grid. Polynomial Regression is not really an interpolator because it does not attempt to predict unknown Z values.

Triangulation with Linear Interpolation. The Triangulation interpolator is an exact interpolator. The method works by creating triangles by drawing lines between data points. The result is a patchwork of triangular faces over the extent of the grid. Each triangle defines a plane over the grid nodes lying within the triangle, with the tilt and elevation of the triangle determined by the three original data points defining the triangle. Evenly distributed data points over the grid area produce the best results with Triangulation. Data sets that contain sparse areas result in distinct triangular facets on a contour map.

Data Sets. Two data sets of face sampled drum tumbler H_2S concentration results obtained from extraction of longwall panels at Mine A and Mine B have been used for this analysis (Gillies, *et al.,* 1997).

In the case of Mine A, H_2S gas was distributed widely within the coal seam. Therefore, equally spaced face samples along the face were collected at five different locations every morning shift during mining of the zone. The positions of five locations selected were chocks 8 (12 m), 38 (57 m), 68 (102 m), 98 (147 m) and 128 (192 m) from maingate (Figure 7).

The data set were found to contain some unreliable results due to delayed testing of some coal samples (sometimes as much as three or four days delays after sampling). Because samples lose gas at a high rate (approx. 50% per day), the delay introduces a wide margin of sampling error. To offset the unreliable sample values, the data set was modified and sample concentration values tested 3 and 4 days after sampling were increased by a factor of 2 and 4, respectively. The purpose of this exercise was to see how corrected sample values affected contour mapping. There were also times when face coal sampling was not undertaken for some days which left a gap in the data set.

The second data set contains the H_2S gas levels from face samples collected from a longwall panel at Mine B while mining through an H_2S zone. The H_2S zone was narrow and cut the longwall panel diagonally (Figure 8). Having learnt from earlier experience a selective and more reliable sampling method could be employed in Mine B than that which evolved at Mine A. The importance of immediately testing freshly collected face samples to produce a reliable data set was recognised.

Selection of a Geostatistical Method for H_2S Distribution Prediction. The Mine A data set was used in the analysis to determine the most suitable geostatistical method that can be used for H_2S distribution prediction. Six contour maps (Figure 9) were produced using various geostatistical methods and results were analysed. From this analysis, Kriging appeared to be the most suitable geostatistical method to model the H_2S distribution. Kriging is a useful tool for mapping irregularly spaced data.

After selecting Kriging as a gridding method, the next step was to select the variogram model that matched the experimental variogram derived from the H_2S levels and to determine the values of the Kriging parameters. The variogram models the spatial variability of the data set. The selection of the variogram model was performed by visual fit of the curve. The nugget effect was established by fitting the tangent at the origin to the curve. The intercept of the tangent at the origin indicates the nugget effect. The sill of the variogram is approximately equal to the variance of the sample.

SURFER provides seven variogram models: Linear, Exponential, Gaussian, Hole Effect, Quadratic, Rational Quadratic and Spherical. Three of these namely the exponential, spherical and quadratic models matched the experimental variogram to a reasonable degree and the exponential model for the variogram was chosen as in most cases it matched the experimental data better than the others.

The spherical model has a long tradition in geostatistics and is frequently used as a robust model for various types of deposits. However, in this study it produced contours that did not match the original data set. Due to a significant nugget effect a smoothing effect is clearly visible and Kriging reveals an overall trend in data instead of repeating sample values at particular nodes.

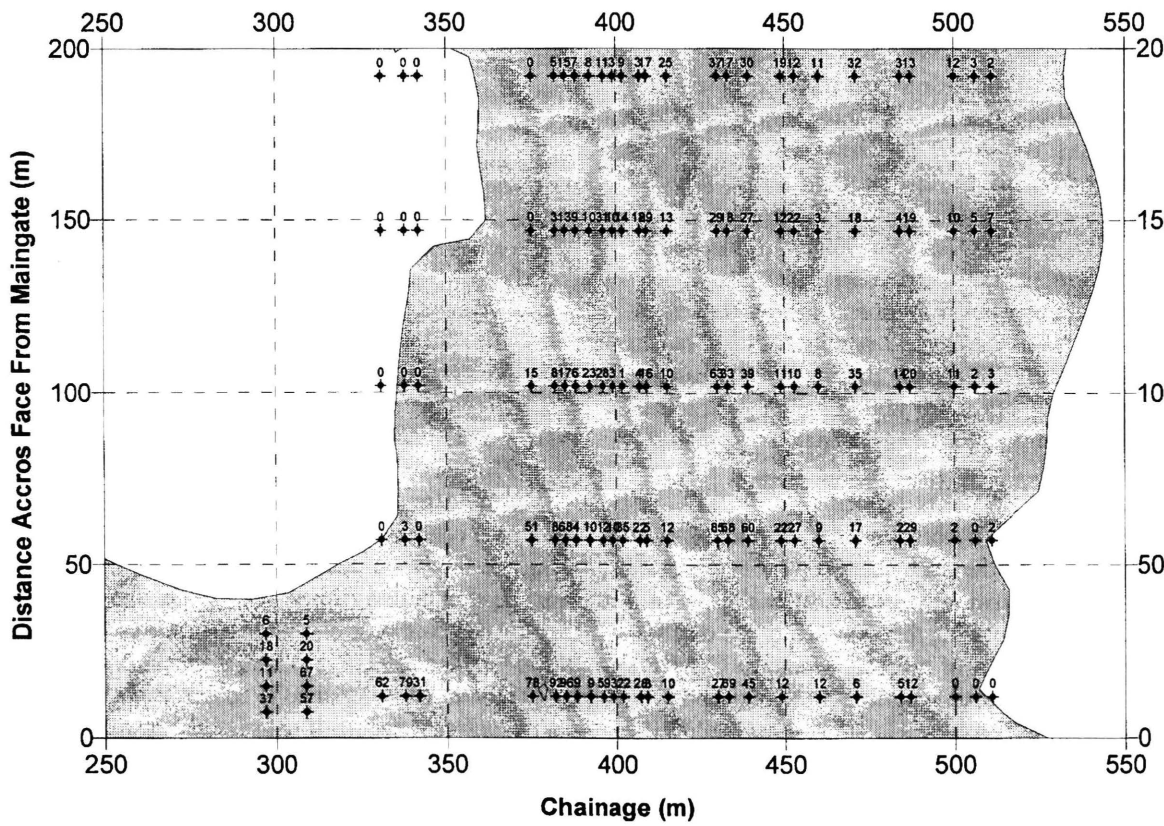


Figure 7. Locations of face samples collected for drum tumbler test at Mine A.

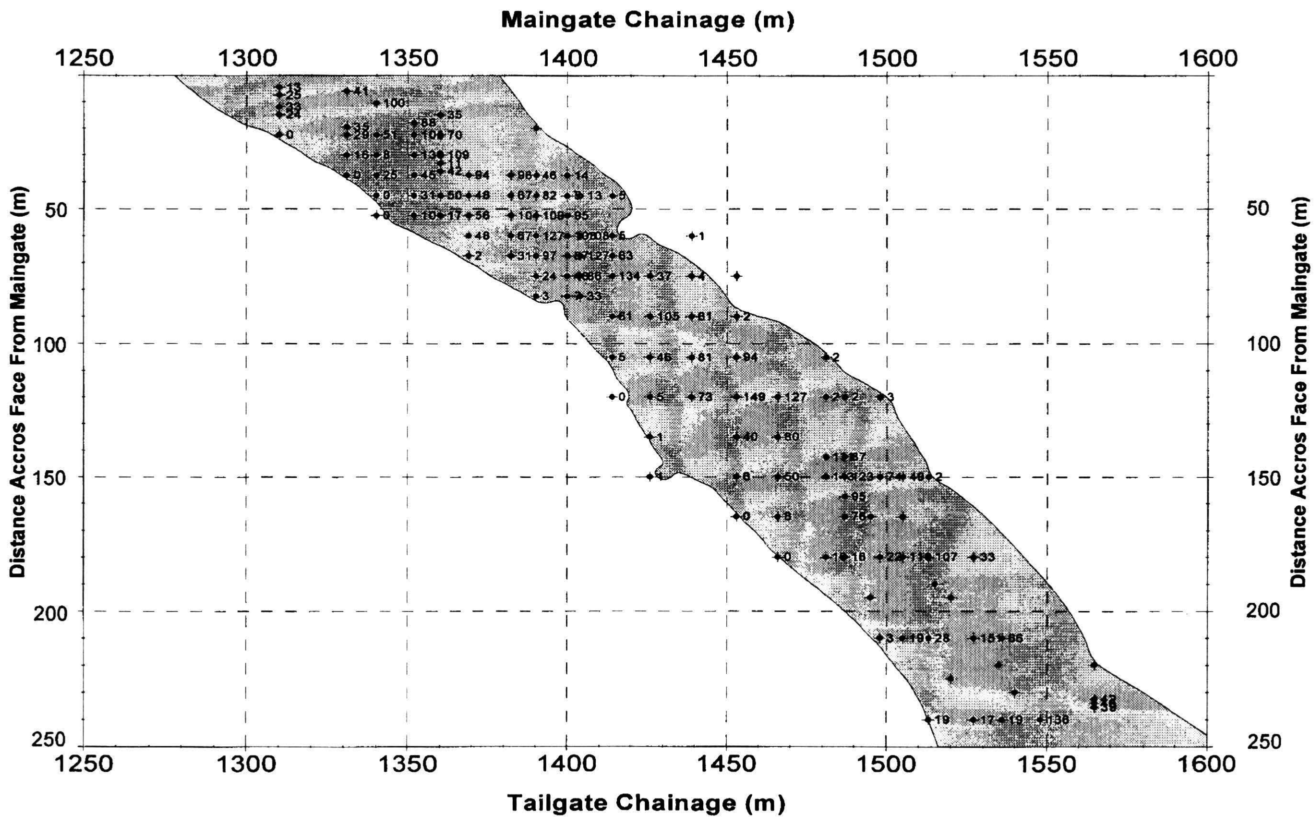
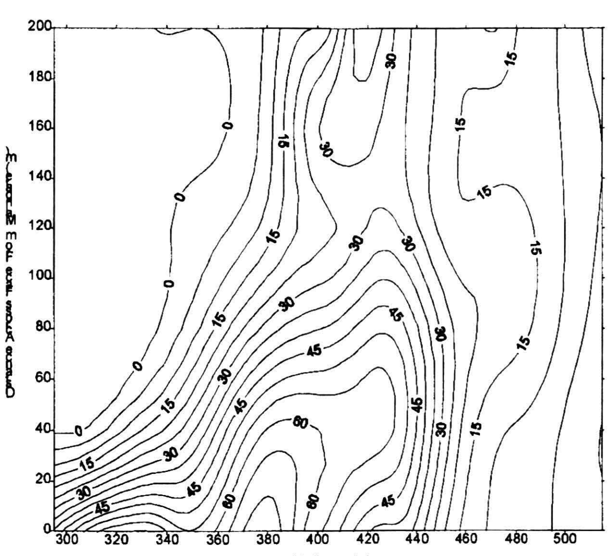
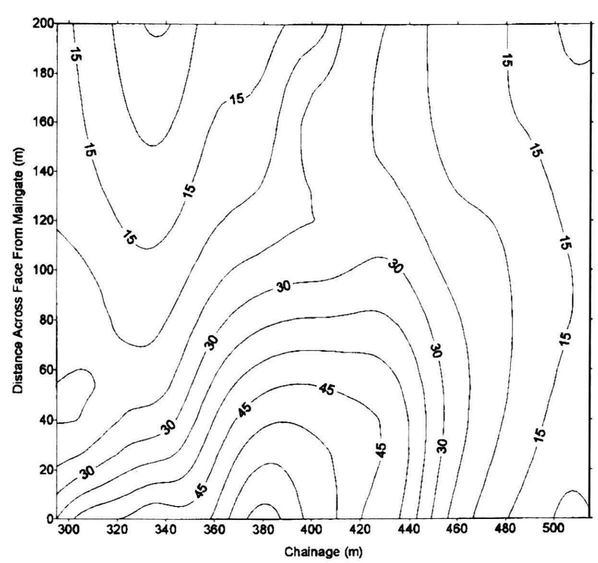


Figure 8. Locations of face samples collected for drum tumbler test at Mine B.



Kriging



Inverse Distance to a Power

Inverse Distance to a Power

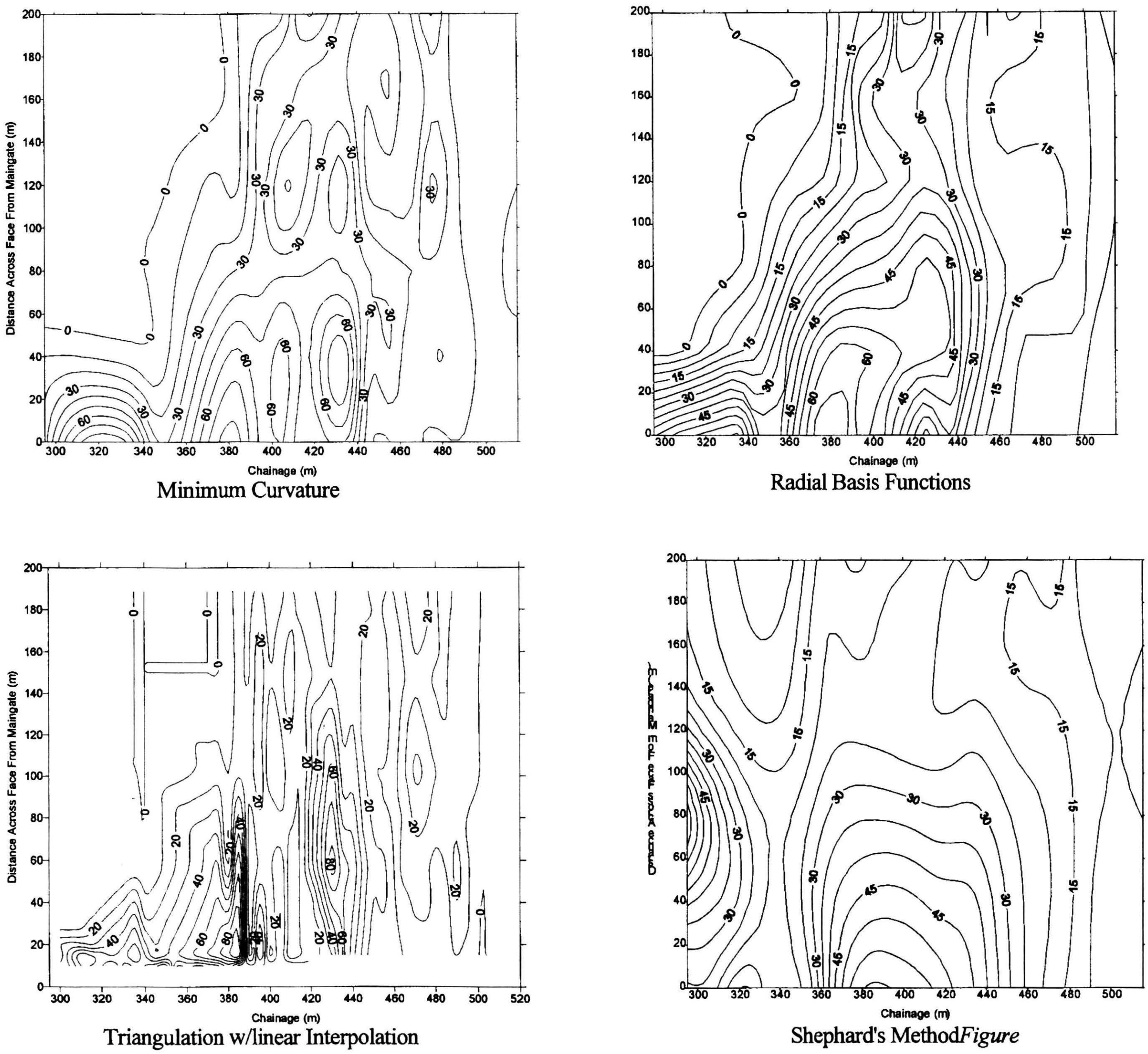


Figure 9. Drum tumbler H_2S results using various geostatistical analysis.

Surprisingly, the linear model, rejected at the variogram analysis stage as least suitable, produced a contour map that matched experimental data. The difference between the spherical and exponential models in terms of fitting the experimental variogram was relatively small, but nevertheless the exponential model fitted better. It provided more realistic results especially at the tailgate side of the panel between chainage distance of 300 and 400 m. However, the unreliable data set renders the search for the best variogram model inconclusive. The choice of variogram model is of paramount importance and weighs heavily on prediction results. Contours maps plotted for different variogram models are presented in Figures 10 to 12.

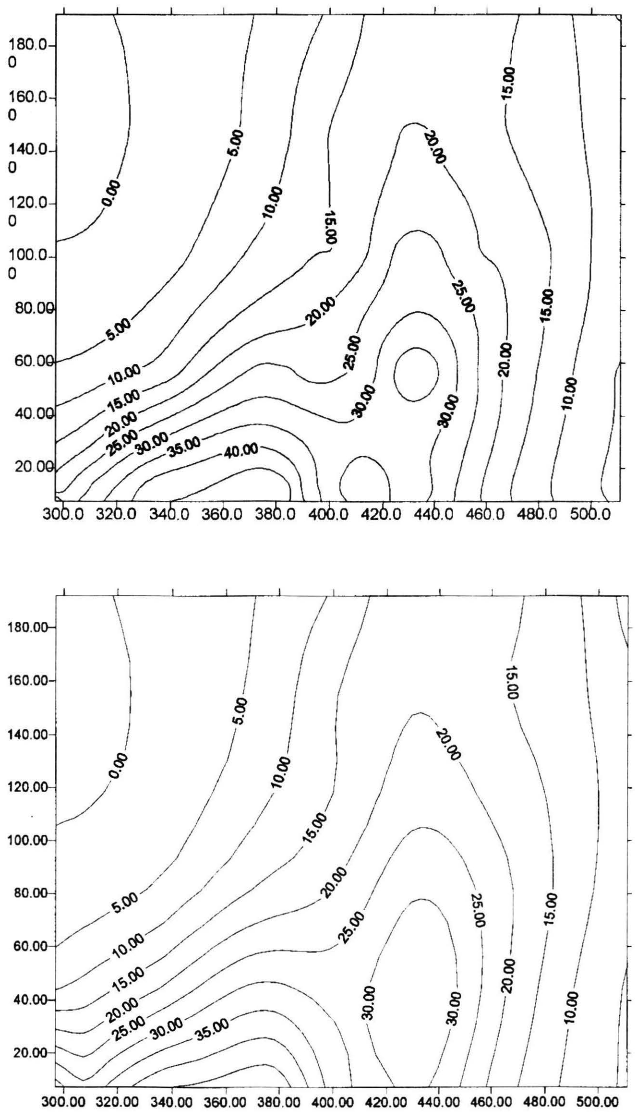


Figure 10. Linear model. Grid-size: 4x4 m (top) and 10x40 m (bottom).

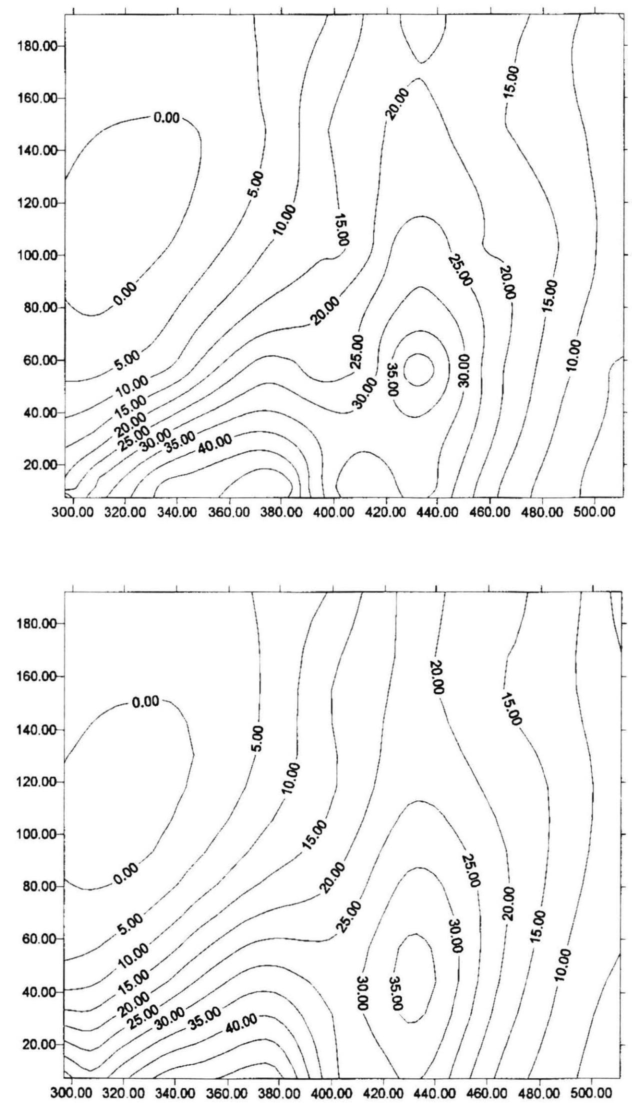


Figure 11. Spherical model. Grid-size: 4x4 m (top) and 10x40 m (bottom).

Three small block samples were extracted from the original data set and the variance was calculated giving extremely different values. The reasonable conclusion seems to be to set the micro-variance value to the value of the sample variance, especially as the size of the sample was relatively small (148 samples).

As it can be seen in Figure 13, the micro-variance has a dramatic effect on contour mapping. With the micro-variance set to zero, the contour map matches better the experimental data distribution. High micro-variance obviously has a smoothing effect and "high peaks" in the data are over-ridden by an overall trend represented in sample values. Despite better match between the sample values and low micro-variance contour map, the smoother map seems more realistic.

The Impact of Grid Size on Results of Data Analysis

The gridding methods included with SURFER can be divided into two general categories, namely Exact Interpolators and Smoothing Interpolators. Some methods can fall under either category depending on the options specified for the individual method. Because SURFER contour maps are created from gridded data and not the original raw data, the original data points might not be honoured exactly by the grid file.

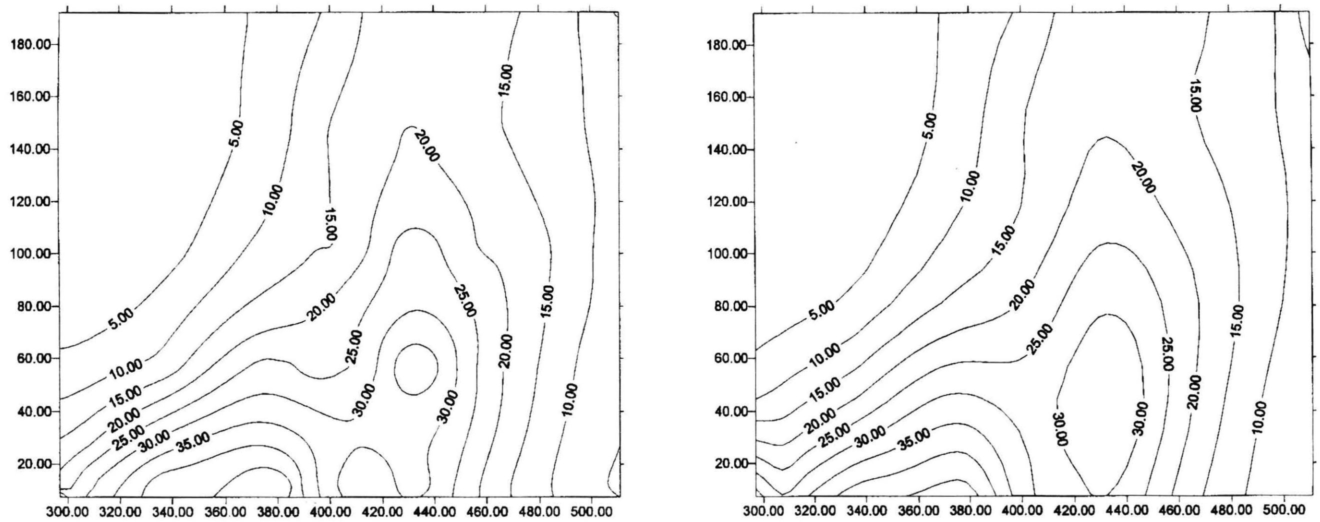


Figure 12. Exponential model. Grid-size: 4x4 m (left) and 10x40 m (right).

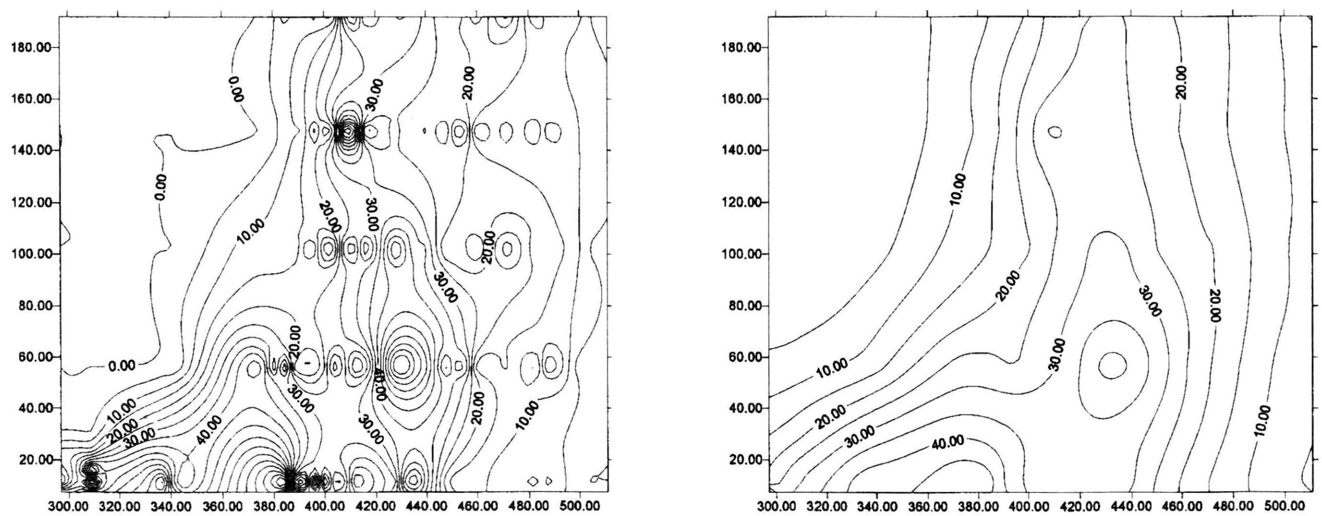


Figure 13. Exponential model. No micro-variance (left) and high micro-variance, equal to sample variance, used in Kriging (right).

For example, if the original data points are posted over the top of a contour map, some of the original data points might be plotted on the "wrong" side of a contour. This happens because the averaging of data values might increase or decrease grid node values in the location of an original data point. The grid points are honoured exactly, but the input data points might not. Exact interpolators can honour data points exactly only when the data point falls directly on a grid node being interpolated. With weighted average interpolators this means that the coincident data point carries a weight of essentially 1.0 and all other data points carry a weight of zero. Data points are applied directly only when the data point and the grid node are exactly coincident. Even when using exact interpolators it is possible that the data is not honoured exactly by the grid file.

To reduce the possibility of not honouring original data points, the number of grid lines in the X and Y direction should be increased. This increases the likelihood that the grid nodes directly overlie original data points, thereby increasing the likelihood that the data points are applied directly to the grid file.

No standard procedure for determining the grid size was found in literature. In that case, it is only reasonable to rely on common sense in choosing the grid-size. If data distribution is fairly regular the average spacing between samples is a good indication as to grid-size. This can be modified according to technical aspects of the analysis such as too large a number of samples. Grid size of a magnitude largely exceeding the average data spacing may be undesirable.

Excessively large grid size has a "smoothing" effect on contour mapping. In other words, values used to draw contours come from interpolation of a large number of samples that tends to average the distribution of the experimental data. This results in loss of information or accuracy. Because the data set of H_2S emissions is relatively regularly spaced, the grid size of average spacing between sample values is recommended. In the analysed sample the average grid is about 4m by 4m, in spite of much larger spacing in Y-axis, about 45 m, in experimental data. This is because SURFER prefers a regular grid and adjusts the grid-size accordingly. The impact of grid-size on contour mapping can be seen in Figure 10 to 12.

The Effects of Anisotropy on the Results

Anisotropy implies that different weighting factors are applied in different directions during gridding. Anisotropy, defined in a specific coordinate direction, is applied by specifying an anisotropy ratio, which gives more weighting to points located along one axis against those located along another axis. In the second data set, the H_2S zone was cutting the longwall panel at approx. 45° to the direction of extraction and all the face samples were collected within the zone defined by a diagonal line across the panel.

When modelling such data set with a unity anisotropy factor the result as shown in Figure 14 is not totally representative and projects a "bull's-eye" effect. In the figure, the dots represent the locations of samples. If the same data set is modelled with an anisotropy factor of 2 or 3 with 45° angle factor, the result becomes more satisfactory (in Figure 15). The contour lines are smoother and the model has better representation of the data set.

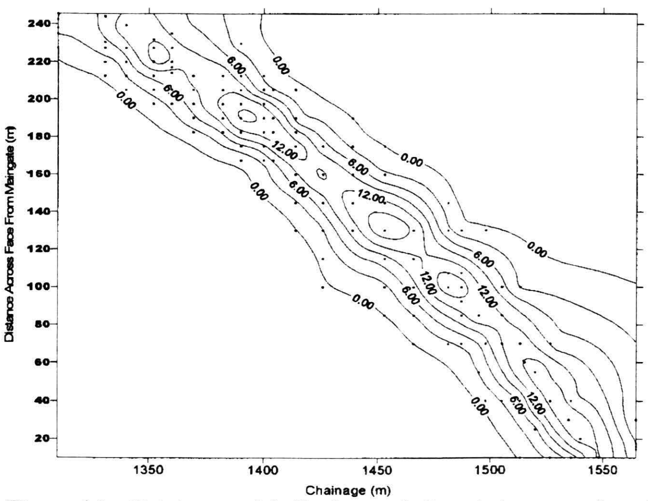


Figure 14. Kriging model. Grid-size: 5x5 m, Anisotropy: 0 and Angle: 0.

COMPARISON BETWEEN PREDICTED, INDICATED AND ACTUAL RESULTS

General observations can be made in comparing "predicted" seam H_2S concentrations from horizontal and vertical drilling sampling, "indicated" concentrations from production face sampling and "actual" liberation rates during mining of the longwall panel. The correlation between the "predicted" model (Figure 16) developed from seven vertical borehole samples (three of which had zero H_2S) and "indicated" model (Figure 17) for Mine A was poor due to insufficient number of vertical borehole samples and possible delay in testing the samples. However, a reasonable correlation was achieved between the Mine B's predicted and indicated models (Figure 18 and 19) derived from 130 core samples collected from 17 in-seam horizontal boreholes.

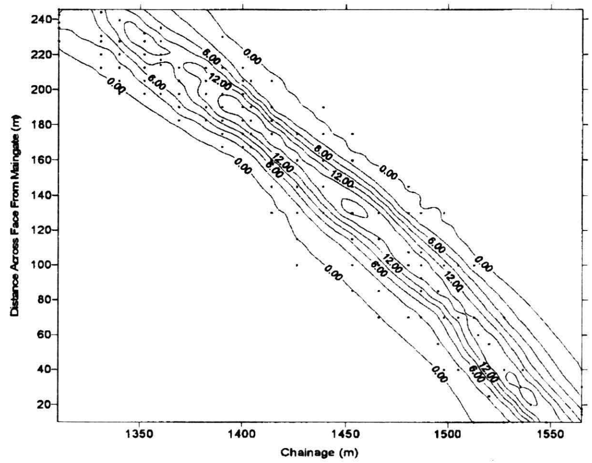


Figure 15. Kriging model. Grid-size: 5x5 m, Anisotropy: 3 and Angle: 315°.

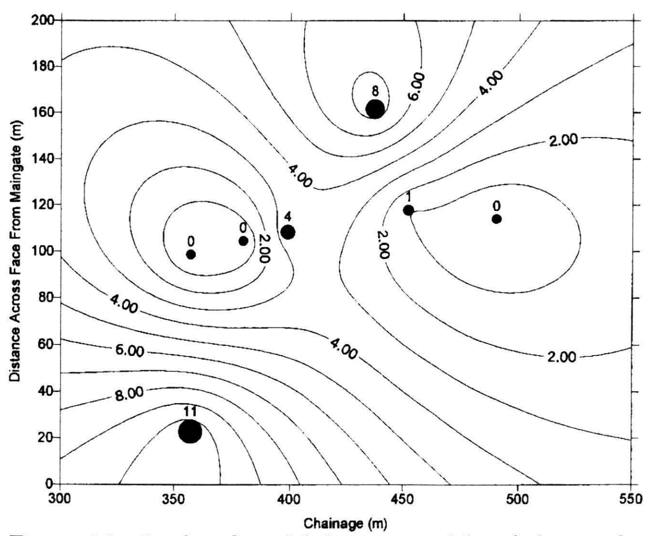


Figure 16. Predicted model from vertical borehole samples. Dots indicate the locations of boreholes.

The actual release is determined by logging coal production, measuring ventilation quantities at regular intervals and monitoring the H_2S levels with electronic instrumentation. The correlation between the results of indicated and actual H_2S released varied. At Mine A the correlation was reasonable while at Mine B it was felt that good correlation was achieved.

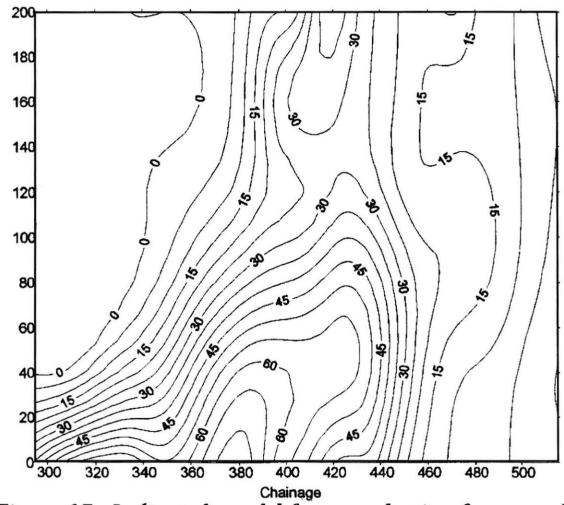


Figure 17. Indicated model from production face samples

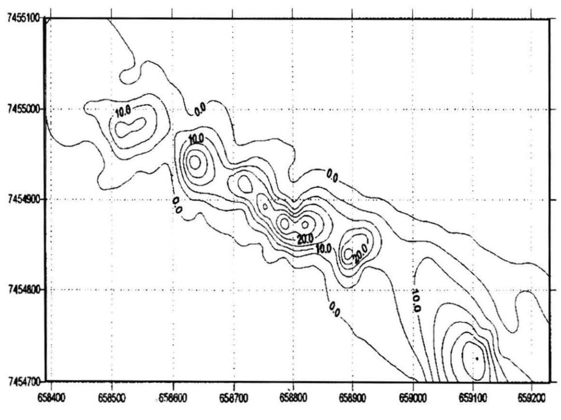


Figure 18. Predicted model from in-seam horizontal borehole samples.

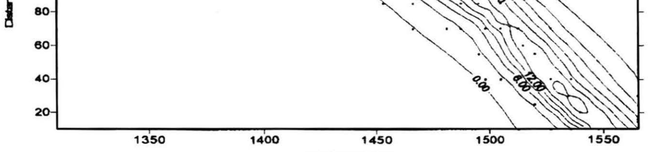


Figure 19. Indicated model from production face samples.

This difference is thought to be mainly due to faster desorption of H_2S from Mine A coal affecting the reliability of the test results.

CONCLUSIONS

A study in data analysis has been undertaken to determine a geostatistical method, which would best represent the "indicated" H_2S seam concentration level from the given data and the block dimension of the data set. This study discusses the different sampling methods used, selection of the most suitable geostatistical method and the impact of grid size on results of data analysis.

Modelling H_2S concentrations with geostatistical approaches was found to be complex due to uncertainties associated with the nature of the technique and errors in sampling and testing. Use of geostatistical analysis has been very beneficial in terms of improving understanding of models of "indicated" H_2S seam concentration levels from the given data. Kriging was a determined to be the most appropriate approach in the modelling of the H_2S data sets. This study has demonstrated that care is needed in applying a geostatistical approach to obtain a valid model. The following points are pertinent.

- Selection of a suitable geostatistical method for modelling H_2S seam gas distribution is not a straightforward process and requires detail analysis. In this case, Kriging was determined to be the most valid model.
- An exponential variogram model provided a reasonably good match with the experimental data.
- The reliability of the data set is the key issue in building a sound prediction model.
- A certain degree of uncertainties and errors in the data set can be successfully handled with the right geostatistical method and variogram model
- Micro-variance has a dramatic effect on contour mapping. High micro-variance has a smoothing effect.
- There is no standard procedure in determining the grid size. Therefore, the average spacing between samples is a good indication as for the grid size. Excessively large grid size has a "smoothing" effect on contour mapping.

Finally, some general observations have been made correlating "indicated" seam H_2S concentrations from production face sampling with predictions made from exploration and with liberation rates during mining of the longwall panel.

ACKNOWLEDGEMENTS