GASIFICATION RISK ASSESSMENT OF TABAS MECHANIZED COAL MINE USING MULTIPLE INDICATOR KRIGING METHOD

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Abstract: This study uses multiple indicator kriging estimator based on assayed data acquired from 48 exploration boreholes in Tabas coal mine in order to predict gas content of coal seams. Results of the estimated block models showed that approximately 12% of the total area has the gas content of less than 5 (m3/ton) (Low risk), 11% has 5-10 (m3/ton) (Medium Risk) and 15% has 10- 15 (m3/ton) (High Risk), while about 62% of total area has the gas content of more than 15(m3/ton) which is of a high risk. Therefore, according to the experiences from mined panels, in the zones with lower to median gasification risk, it is possible to keep the mining operation running with management and optimization of the ventilation system. However, in the zones with higher gasification rate, demethanization process is mandatory.

Keywords: Gas content, Geostatistics, Multiple indicator Kriging, Mechanized Tabas coal mine.

INTRODUCTION

In all countries, one of the hazardous industrial activities is mining, especially underground coal mining. Various incidents have made coal mining dangerous all over the world, mainly when extracting high-gas zones. According to the NCMA in 2008, accidents caused by the gas explosion in coal mines was one of the main life hazards in China, that the number of accidents and deaths from these hazards has been 82.58%, and 51.5% of the total risk in the mines. Therefore, in coal mines the most important task before extraction is to create a safe environment for work. So in underground mines the prediction of gas content before extraction has a significant effect on maintaining safety and meeting production plans at the same time. There are several methods for estimating gas contents, among which is Kriging method, one of most widely used approaches. Long delays and periodic pauses of extraction operations on W1 panel due to the high level of gasification in the mechanized coal mine of Tabas has led to a reduction in efficiency, and it is expected that as the operation advances in the deeper panels of the mine, gasification problem becomes even worse. Therefore, in this study, Kriging method is used to predict the amount of gas content in non-extracted panels of Tabas mechanized coal mine and also to asses risks accordingly. Multiple index Kriging method was selected among a wide range of geostatistical methods because the data fails to follow the normal distribution function, and there is a problem first with the data trends and then with multi-community of the data sets. One of the important advantages of Kriging method is that it is applicable regardless of assumptions such as normal data.

METHODS

Based on the data set conditions, the most suitable estimator was the multiple indicator Kriging method. The use of this method requires the conversion of quantitative data into multiple indicators based on threshold values. In the definitions of the indices, the gas content associated with the nine quintiles was used in the data set. After converting the gas data to the 9th indicator variable for the structural analysis of these indicators, the structure of each was individually analyzed. Variogram, as the structural analysis tool, enables the verification of spatial autocorrelation between the measured points. In spatial self-dependence, it is assumed that objects closer to each other are more similar to each other [12]. Therefore, the variogram can be used to examine the local spatial properties of a dataset, for example, to determine the optimal sampling distance in the area where the data is spatially correlated, taking into account the effect of anisotropy, to be used, which is defined as followed [13]:

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i) - Z(x_i + h)]^2$$

where $\gamma(h)$ is the value of the semi-variogram for lag *h*, *N* is the pair of samples spaced at a distance *h* from each other, *Z(x)* is also the value of the Z variable at the point to the coordinates *x*. After estimating the probability of an exceedance of each of the nine thresholds, the E-Type value, $Z_E^*(x)$ which estimates the amount of gas content at each unsampled position, could be calculated based on the following equation:

$$Z_E^*(x) = \sum_{k=1}^{N+1} \overline{Z_k} [I^*(x; z_k) - I^*(x; z_{k-1})]$$

where $I^*(x; z_k)$ is the estimated probability of aggression of gas amount in position x of the threshold value of Z_k, $\overline{z}_k$ is the mean value of the kth interval which is between the threshold values of *(k-1)* and *k*. Another output of the multiple indicator Kriging method is the value of the conditional variance, which could be calculated based on the following equation:

$$S_{IK}^2(x) = \sum_{k=1}^{N+1} (\overline{Z_k} - Z_E^*(x))^2 [I^*(x; z_k) - I^*(x; z_{k-1})]$$

FINDINGS AND ARGUMENT

After accurate geostatistical analysis on gasification data, the final prediction map of the gasification in mechanized coal mine of Tabas was produced. In Figure 1, the E-Type variations of coal gasification are shown. As observed, by increasing the depth of the mine, the amount of gas boosts. In addition to the prediction of variables, the variability of predictions from measured values could be estimated based on the conditional variance. In Fig. 2, the value of the conditional variance of predictions is shown. As seen in this figure, there are few points with higher variance, due to the lack of data in the neighboring zone.

Generally, the results of the gas estimating scheme showed that in approximately 12% of the total studied area, gasification is less than 5 (m3/ton), in 11% of the area gasification is 5-10 (m3/ton), and 15% of the area has a gas content of 10-15(m3/ton). While about 62% of the total area under studies has a high gas content (15 m3/ton) (Table 1).

Table 1. The results of the gas estimation for risk assessment

Rick Value	Percentage of the Total Area (%)	Block Number	Gas Content (m3/ton)
Low	12	286	0-5
Average	11	258	5-10
High	15	377	10-15
Very high	62	1510	>15

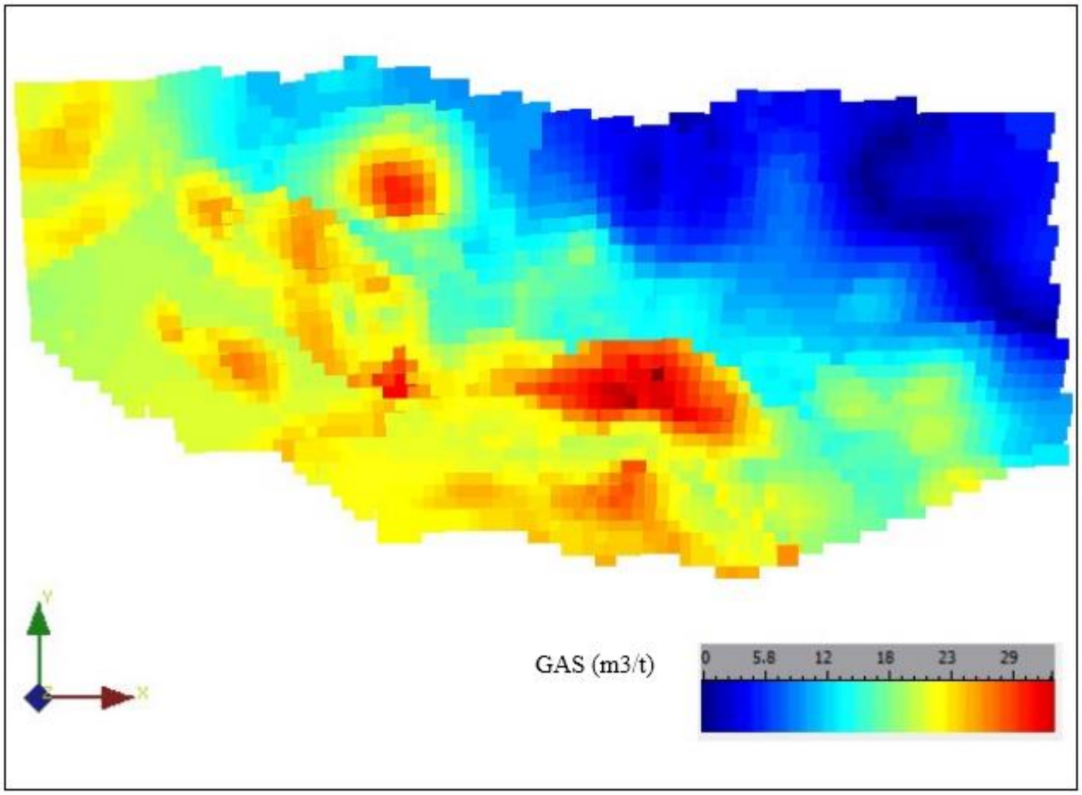

Fig.1 Prediction map of gas content

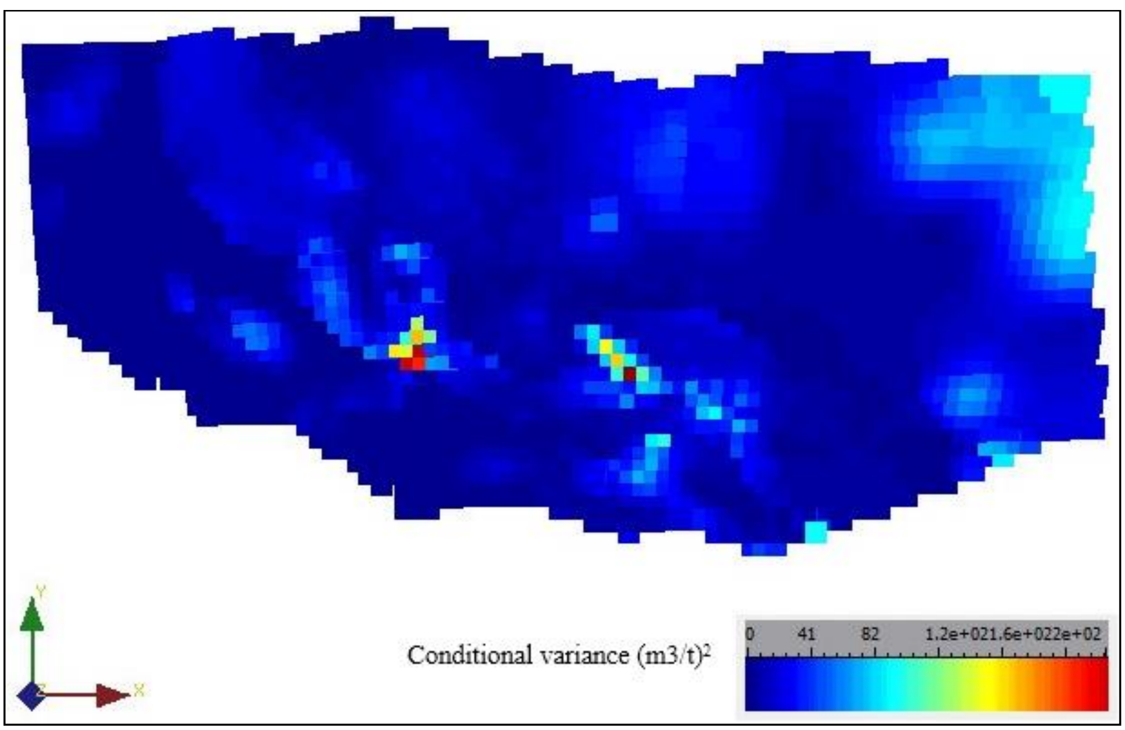

Fig.2 Condition variance of gas content of the mechanized coal mine of Tabas

CONCLUSIONS

In this research, gasification rate of Tabas mechanized coal mine was predicted by statistical techniques. After reviewing the data, due to the multi-communicational nature of the data, the non-normalization and the existence of data trends, the data was converted to multiple indicator variables and gas content was estimated by multiple indicator Kriging method. In general, the results of the prediction map indicated high gas production and risk levels in Tabas mine. So, even at shallow depths, the amount of gas content is high, and for every 100 meters from surface, gas volume increases 2(m^3/ ton). This amount of gasification is higher than the global standards. Finally, the gas content prediction map showed that 62% of the area has a gasification rate of more than 15 m^3/ton. In general, this mine requires the implementation of a methane drainage system in order to reduce the risk of gasification, and consequently, to reduce the likelihood of unforeseen incidents.

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