M|T|J

*Mining Technology Journal*
*Vol.(I): Hal 1-10. https://doi.org/10.31315/jilk.v3i2.4302*
***E-ISSN: 2460 - 8386***
http://jurnal.upnyk.ac.id/index.php/mtj

# Optimization of Information Point Distances in the Estimation and Classification of Coal Resources Using Geostatistical Methods Compared to SNI 5015:2019 for Moderate Geological Conditions

**Michael Jerrycho Purba[1,*] and Eko Wicaksono[2]**
[1]*Department of Mining Engineering, Faculty of Engineering, Universitas Sriwijaya. Jl. Palembang-Prabumulih Km 32, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia.*
[2]*Mining Engineering Master's Program, Universitas Pembangunan Nasional "Veteran" Yogyakarta Jl. SWK 104 Condong Catur, Yogyakarta. 55283, Yogyakarta, Indonesia.*
[*]Corresponding author: michaeljerrycho82@gmail.com

## ARTICLE INFO

Received: 17-03-2022

Accepted: 01-06– 2022

**Keywords:** Coal Estimation, Global Estimation Variance, Classification, Kriging Relative Error

## ABSTRACT

The reference currently used in estimating and classifying coal resources in Indonesia is SNI 5015:2019, which refers to the Australian Guidelines for Estimating and Reporting of Inventory Coal, Coal Resources, and Coal Reserves, 2003 Edition. However, several changes have emerged with the issuance of The JORC Code, 2012 Edition and Australian Guidelines for The Estimation and Classification of Coal Resources, 2014 Edition. One of the changes is in calculating geostatistical aspects in the estimation and classification of coal resources. In this study will be discussed about the need for the use of geostatistical methods and evaluation of SNI 5015:2019. The purpose of this study is to determine the optimal borehole spacing, determine the classification and estimation of resources using the geostatistical method, and compare it with SNI 5015:2019. The method used is the kriging relative error method and global estimation variance. The two methods give different results from SNI 5015:2019. This thing exactly gives different resource estimation results. This difference indicates the need to evaluate the classification and estimation system of SNI 5015:2019, especially related to the use of geostatistical methods accompanied by geological interpretations that describe the actual state of the research location.

CONTACT Michael Jerrycho Purba | michaeljerrycho82@gmail.com |Department of Mining Engineering, Faculty of Engineering, Universitas Sriwijaya, South Sumatra, Indonesia

## INTRODUCTION

In the coal resources classification, Indonesia still refers to SNI 5015:2019 [2], which only considers aspects of geological conditions in the classification system while other factors such as quality continuity such as inherent moisture, volatile matters, calory value, and others are not particular aspects of the assessment in determining the distance of information points (area of influence). The Australian Guidelines for the Estimation and Classification of Coal Resources 2014 Edition [4] document itself has used geostatistical aspects in specific considerations regarding the determination of the distance of information points for resource classification, where this will undoubtedly make a justification in the estimation and classification of resources relevant and closer to the actual situation. In response to this, this study was carried out to optimize the distance of information points in the estimation and classification of resources in an area with the Global Estimation Variance (GEV) method in order to obtain the optimal distance of information points and under the characteristics of data distribution and actual geological conditions and compare the results with SNI. 5015:2019.

## LITERATURE REVIEW

Univariate statistics is a statistical method used to analyze the relationship between each data from a population regardless of the location of the data. It consists of two types, namely measures of central tendencies (central tendency) such as mean, median, and data variance measures (scatter) such as standard deviation variance, slope (skewness), and coefficient of variance (covariance). Meanwhile, bivariate statistics aims to see whether or not there is a correlation between parameter Y and parameter X, and this determines whether or not data accumulation is necessary due to similar data characteristics [9]. In carrying out geostatistical analysis, especially in semivariogram fittings, the univariate and bivariate statistical analysis must be carried out first to see each data's characteristics and correlations and not produce biased data and seem overconfident vice versa. Meanwhile, in SNI 5015:2019, the classification of resources is divided based on different geological conditions with Diehl and David [7] (Table 1) or de Souza et al. [6] (Table 2), who classify coal resources based on the level of error (relative error). it considers aspects of spatial data correlation in its analysis and decision making.

**Table 1.** Resource Classification Based on Error Value and Confidence Level (Diehl & David 1982)

<table>
<tr><td rowspan="4">Recources</td><td colspan="3">Identified</td><td colspan="2">Undiscovered</td></tr>
<tr><td colspan="2">Demonstrated</td><td colspan="3" rowspan="2"></td></tr>
<tr><td>Measured</td><td rowspan="2">Indicated<br>(possible)</td></tr>
<tr><td>proved probable</td><td>Inferred</td><td>Hypothetic</td><td>Specul</td></tr>
<tr><td>Error tolerance</td><td>± 10% ±20%</td><td>± 40%</td><td>±60%</td><td></td><td></td></tr>
<tr><td>Confidence level</td><td>>80% 60-80%</td><td>40-60%</td><td>20-40%</td><td>10-20%</td><td><10%</td></tr>
<tr><td></td><td colspan="3">Economically significant resources</td><td colspan="2">Resources base</td></tr>
</table>

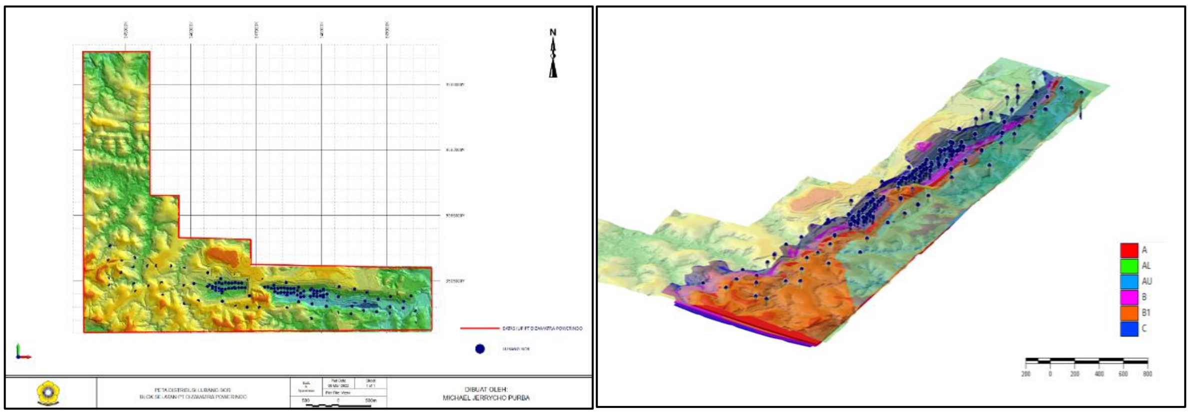
**Table 2.** Resource Classification Based on Error Value ( de Souza dkk. 2004)

| Resource Classification | Maximum Estrapolation Distance | Maximum Spce Of Information Points | *Error tolerance* |
|---|---|---|---|
| *Measured* | 500 m | +1 km:<500m | 0-10% |
| *Indicated* | 1000 m | +2 km:<1 km | 10-20% |
| *Inferred* | 2000 m | +4 km | >20% |

# RESEARCH METHODOLOGY

The coal seams studied in this study were A, B, and C seams in a mine in the Lahat area, South Sumatra. The initial input data prepared in this study were:

- Model of coal deposit form in the form of Seam Block Model
- Exploration data such as data collar, quality, and lithology of coal deposits
- Concession map data (IUP) of the area under study
- Geological maps and geological characteristics of the area under study




(a) (b)

**Figure 1.** Distribution of Boreholes in Study Area (a) The Model of Coal Deposit in The Study Area (b)

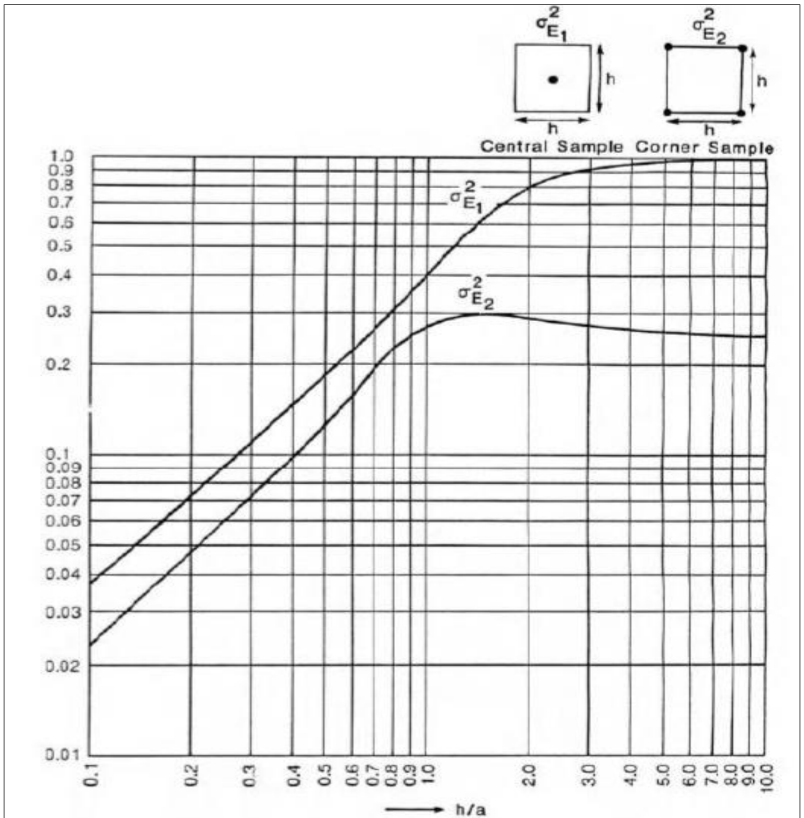
Through the calculation of Global Estimation Variance (GEV) will be obtained relative error values [8] which obtained from several processes ranging from data preparation using univariate and bivariate statistical analysis, fitting the variogram, determining the estimated variance ($\sigma_E^2$) with an extension variance nomogram (estimation of variance). ) with nugget 0 and sill [1] (Figure 2), adjust the nugget and sill for each parameter using and generate the estimated variance for that parameter then ($\sigma_r^2$) (1) determine the global variance of the study area ($\sigma_R^2$) (2) and ends with the determination of the relative error (3)[5].

After determining the relative error, the Drill Hole Spacing Analysis (DHSA) will be carried out on each seam and obtain results in the form of information point distances for each coal resource classification. The end of the research process is to obtain tonnage by estimating and classifying resources using the relative error method and SNI 5015:2019.

$$\sigma_E^2 r = C0 + (C\ x\sigma_E^2\ ) \tag{1}$$

$$\sigma_E^2 R = \frac{\sigma_E^2 r}{N} \tag{2}$$

$$Relative\ Error = \pm\ 1.96\ .\ \sigma_E\ .\frac{100\ \%}{Mean} \tag{3}$$




**Gambar 3.12** Nomogram Nilai Varian Ekstensi/Estimasi ($\sigma_e^2$) Titik Terhadap Bidang Bujur Sangkar untuk Model *Spherical* (Annels, 1991)

**Figure 2.** Nomogram of Extension Variant Value Towards Square Field with Spherical Variogram Model

## FINDING AND DISCUSSION

### Descriptive Statistics Analysis

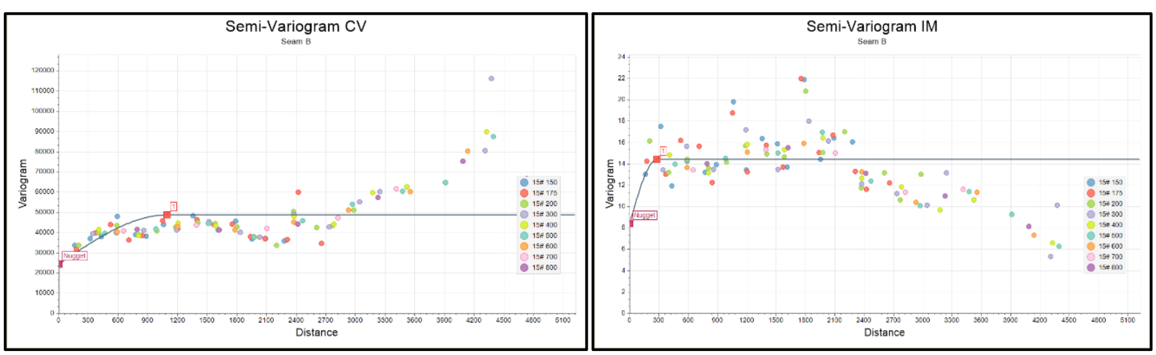
This analysis was carried out on seam A, seam B, and seam C and based on coal quality data, including volatile matters, inherent moisture, fixed carbon, and calories (calory value). And the geometry is the thickness and relative density of each coal seam at the research location. The quality and thickness data for seam A amounted to 140 data, for seam B totaled 173 data, and seam C, totaled 74 data. Univariate statistical analysis is intended to consider the value of random or random data regardless of the location of a sample. The results of descriptive statistical analysis for each seam's quality and geometry data can be seen in Table 3. The first parameter that will be the center of the analysis is the coefficient of variation. From the numerical series, all parameters on all seams have a coefficient of variation smaller than 1.5, so it can be said that the existing data is still within normal limits, so there is no need to cut outliers for the upper and lower limits of descriptive statistical data for each coal seam, and this can also be a justification that all data can be used in the further analysis [8]. From the results of the descriptive statistics of Seam A, it can be seen that there is a reasonably good distribution of data on each parameter that can reflect the level of data continuity. This is indicated by the coefficient of variation of each parameter, where the value is still less than 0.5. As is known, the coefficient of variance can indicate the condition of the distribution (variability) of the existing data. A high coefficient of variance indicates a wide distribution of data.

**Table 3.** Descriptive Statistics Seam A, B, and, C

| Quality | Seam | Minimum | Maximum | N | Mean | Variance | Std Dev | Weighted Mean | Coeff. of Variation | Mode | Median |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CV | A | 4,015.00 | 5,119.00 | 140 | 4,559.0 | 40,174.34 | 200.44 | 4,565.05 | 0.044 | 4,582.00 | 4,563.50 |
| FC | A | 33.14 | 43.15 | 140 | 38.20 | 5.09 | 2.26 | 38.16 | 0.059 | 36.60 | 38.16 |
| IM | A | 9.14 | 25.03 | 140 | 17.90 | 13.80 | 3.72 | 17.97 | 0.208 | 19.41 | 18.47 |
| RD | A | 1.03 | 1.27 | 140 | 1.16 | 0.01 | 0.08 | 1.16 | 0.065 | 1.27 | 1.14 |
| VM | A | 32.48 | 47.07 | 140 | 39.06 | 6.14 | 2.48 | 38.99 | 0.063 | 38.72 | 38.71 |
| THICKNESS | A | 4.27 | 16.20 | 140 | 13.50 | 2.08 | 1.44 | 13.50 | 0.107 | 14.19 | 13.70 |
| CV | B | 3,843.00 | 5,117.00 | 173 | 4,618.0 | 44,731.52 | 211.50 | 4,616.44 | 0.046 | 4,627.04 | 4,638.00 |
| FC | B | 32.13 | 44.15 | 173 | 37.12 | 7.41 | 2.72 | 37.05 | 0.073 | 35.20 | 36.58 |
| IM | B | 9.99 | 24.94 | 173 | 17.52 | 13.43 | 3.67 | 17.56 | 0.209 | 19.81 | 18.38 |
| RD | B | 1.05 | 1.34 | 173 | 1.17 | 0.00 | 0.06 | 1.17 | 0.053 | 1.25 | 1.17 |
| VM | B | 2.52 | 47.36 | 173 | 38.26 | 46.38 | 6.81 | 38.30 | 0.178 | 39.52 | 39.30 |
| THICKNESS | B | 10.67 | 20.00 | 173 | 17.56 | 2.12 | 1.46 | 17.56 | 0.083 | 18.60 | 17.60 |
| CV | C | 4,053.00 | 5,359.00 | 74 | 4,635.0 | 54,290.20 | 233.00 | 4,636.89 | 0.050 | 4,583.04 | 4,628.00 |
| FC | C | 25.73 | 42.81 | 74 | 37.15 | 6.28 | 2.51 | 37.17 | 0.067 | 35.42 | 37.25 |
| IM | C | 9.67 | 23.88 | 74 | 18.59 | 9.90 | 3.15 | 18.49 | 0.169 | 13.80 | 18.91 |
| RD | C | 1.02 | 1.24 | 74 | 1.12 | 0.00 | 0.05 | 1.12 | 0.042 | 1.14 | 1.12 |
| VM | C | 34.78 | 43.79 | 74 | 38.47 | 3.10 | 1.76 | 38.54 | 0.046 | 36.10 | 38.50 |
| THICKNESS | C | 4.15 | 9.05 | 74 | 7.44 | 1.35 | 1.16 | 7.44 | 0.156 | 7.90 | 7.90 |

## Variogram and Geostatistics

The statistical description presented in the previous discussion is a description that is only based on the results of the quality analysis, without regard to the position (location) of the distribution of the data [9]. To find out the pattern of data distribution, geostatic analysis can be used so that the direction and variation of the data distribution (anisotropy/isotoropy) can be known. The importance of the geostatistical method is because it also considers the position of the distribution of the data so that the direction and variation of the data distribution can be known. In contrast to the results of statistical analysis, which only describes data based on the quality analysis results only. The analyzed variables are geometry data and quality data, ignoring the borehole position that does not have quality or geometry data.




(a) (b)

**Figure 3.** Distribution of Boreholes in The Study Area (a) The Model of The Coal Deposit in The Study Area (b)

**Table 4.** Omni-Directional Semivariogram Parameters

| Seam | Parameter | Model | Nugget | Sill | Range | CoV |
|---|---|---|---|---|---|---|
| A | CV | *Spherical* | 3264.029514 | 51804 | 708.125 | 0.04 |
| A | FC | *Spherical* | 4.156196218 | 5.36265 | 168.643 | 0.06 |
| A | IM | *Spherical* | 5.55740048 | 15.1882 | 311.481 | 0.21 |
| A | RD | *Spherical* | 0 | 0.006486648 | 429.289 | 0.06 |
| A | VM | *Spherical* | 2.953119975 | 6.63481 | 323.921 | 0.06 |
| A | THICKNESS | *Spherical* | 0.585466039 | 2.4972 | 273.651 | 0.11 |
| B | CV | *Spherical* | 24485.42142 | 48725.2 | 1092.743 | 0.05 |
| B | FC | *Spherical* | 4.216893915 | 7.91191 | 160.397 | 0.07 |
| B | IM | *Spherical* | 8.439269816 | 14.429 | 278.923 | 0.21 |
| B | RD | *Spherical* | 0.000899054 | 0.004246 | 644.398 | 0.05 |
| B | VM | *Spherical* | 0 | 58.5223 | 286.071 | 0.18 |
| B | THICKNESS | *Spherical* | 1.254148568 | 2.34073 | 160.397 | 0.08 |
| C | CV | *Spherical* | 761.7659045 | 85524 | 1447.216 | 0.05 |
| C | FC | *Spherical* | 0 | 6.998202211 | 521.619 | 0.07 |
| C | IM | *Spherical* | 0 | 11.2450298 | 541.003 | 0.17 |
| C | RD | *Spherical* | 0.00045992 | 0.00236249 | 309.441 | 0.04 |
| C | VM | *Spherical* | 0 | 3.37091 | 478.947 | 0.05 |
| C | THICKNESS | *Spherical* | 0.271259246 | 1.74266 | 1372.898 | 0.16 |

fitting process is carried out in the azimuth direction of N 0°E, dip 0°, and angle tolerance of 90° (Omni-directional). The maximum distance is ± 800 m with a lag distance of 50-100 m (based on data distribution and the average drill hole distance), and the number of lags varies to facilitate the variogram fitting. From the results of the variogram fitting, the range, sill, and nugget variance values will be obtained.

## Global Estimation Variance dan Relative Error

The global estimation variance (GEV) obtained from calculations based on the nomogram model is then used to estimate the relative error value. Next, the plotting between the relative error values and the borehole spacing is carried out to create a Drill Hole Spacing Analysis (DHSA) graph. From the DHSA graph, it is then known that the area of influence is for measured, indicated, and inferred resources, with the relative error values being less than 10% (measured), 10-20% (indicated/indicated), and 20-50. % (inferred). According to Bertolli [3], the borehole spacing reaches the optimum point when the relative error value is exactly ±10% for the measured, ±20% for indicated, and ±50% for inferred. The geostatistical parameters for the nugget variance (c0), sill (c), and range (a) values obtained from the variogram fitting results will be used in the following process to determine the optimum drill distance, which is entered in the calculation table (Table 5) with the Global Estimation method. Variance (GEV) calculates the relative error value and determines the optimum drill spacing. The description of table 5 below is the mean value taken from descriptive statistics for each parameter of seam A, seam B, and seam C, while h and l are drill spacings which are added up in multiples of 100 m assuming h & l are the same areas. The value of _X is the difference between the maximum X and minimum X coordinates divided by the borehole spacing, and _Y is the difference between the maximum Y and minimum Y coordinates divided by the drill spacing. The value of N is the product of _X and _Y.

Furthermore, the parameters obtained from the variogram fitting results are entered, namely range (a), nugget variance (C0), and sill (C). Furthermore, the extension/estimated variance is obtained by reading the drill spacing (h)/range (a) on the nomogram, as shown in Figure 2. Furthermore, the value of the variance of the point estimate to the planned plane of the drill spacing projection (r) must be adjusted again with the nugget variance and sill values for each parameter. After that, looking for the global estimation variance with the ratio between the point estimate variance value to the field and the amount of data (N) will produce a global estimate variance (R). Then perform calculations on the value of the global standard deviation, which is the square root of the global estimated variance (R). The last calculation stage is to find the relative error value by multiplying the confidence level, which is a constant 1.96, then multiplied by the standard deviation divided by the average value of the quality or thickness parameter obtained from descriptive statistical calculations, so in the end you will get the relative error value for each distance multiple. 100 meters. The results of the calculation of the relative error value will then be made a graph of the Drill Hole Spacing Analysis (DHSA) graph in logarithmic form using Microsoft Excel software based on the theory of Bertolli et al. [3] and Cornah et al. [5] as in Figure 4 for DHSA seam A.

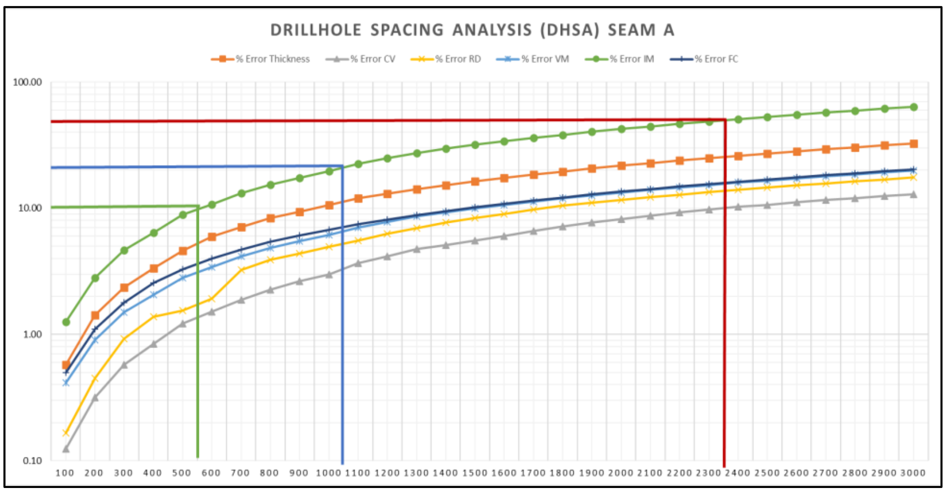



**Figure 4.** Seam A Drillhole Spacing Analysis Chart

## Drillhole Spacing Analysis Chart

The second stage is creating a DHSA chart that also uses excel by reading the drill spacing values and the relative error of the four quality parameters and one thickness parameter. To draw drill spacing lines based on relative error based on Bertolli's theory [3] by reading the distance reached by the relative error value when it reaches the values of 10%, 20%, and 50%, then that is the optimum distance. This graph was created using Microsoft Excel software by reading the drill spacing values (x-axis) and relative error (y-axis) of the four quality parameters and one geometry parameter. To draw drill spacing lines based on a relative error, namely based on Bertolli's (2013) theory, namely reading the distance reached by the relative error value when it reaches the value of 10%, 20%, and 50%, then the distance is the optimum for each resource. From the graph in Figure 4, we get the optimum distance of information points (drill hole sampling) for seam A, for resource classification measured at a distance of 500 m, indicated at a distance of 1000 m, and inferred at a distance of 2300 m. From the graph, it can also be concluded that the low the distance radius of the information point (range) owned by IM is in line with the high CoV (coefficient of variation) of the inherent moisture itself, which is shown in table 4, which is indeed the highest CoV in seam A, it can be justified that the range will be shorter with increasing the value of the coefficient of variation (CoV) of a parameter.

**Table 5.** The Example of Global Estmation Variance and Relative Error Seam A (Thickness)

| Mean | h | l | _X | _Y | N | a | C0 | C | h/a | i/a | Varian Ekstensi | [illegible] (r) | [illegible] (R) | [illegible] ( (R) | % Relative Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13.50 | 100 | 100 | 46.9083 | 11.7147 | 549.5167 | 273.651 | 0.585466 | 2.4972 | 0.37 | 0.37 | 0.110 | 0.860158 | 0.001565 | 0.039564 | 0.574323598 |
| 13.50 | z | 200 | 23.45415 | 5.85735 | 137.3792 | 273.651 | 0.585466 | 2.4972 | 0.73 | 0.73 | 0.290 | 1.309654 | 0.009533 | 0.097638 | 1.417345809 |
| 13.50 | 300 | 300 | 15.6361 | 3.9049 | 61.05741 | 273.651 | 0.585466 | 2.4972 | 1.10 | 1.10 | 0.410 | 1.609318 | 0.026357 | 0.16235 | 2.356729453 |
| 13.50 | 400 | 400 | 11.72708 | 2.928675 | 34.34479 | 273.651 | 0.585466 | 2.4972 | 1.46 | 1.46 | 0.500 | 1.834066 | 0.053402 | 0.231088 | 3.354555727 |
| 13.50 | 500 | 500 | 9.38166 | 2.34294 | 21.98067 | 273.651 | 0.585466 | 2.4972 | 1.83 | 1.83 | 0.650 | 2.208646 | 0.100481 | 0.316988 | 4.601512432 |
| 13.50 | 600 | 600 | 7.81805 | 1.95245 | 15.26435 | 273.651 | 0.585466 | 2.4972 | 2.19 | 2.19 | 0.800 | 2.583226 | 0.169233 | 0.411379 | 5.971727615 |
| 13.50 | 700 | 700 | 6.701186 | 1.673529 | 11.21463 | 273.651 | 0.585466 | 2.4972 | 2.56 | 2.56 | 0.850 | 2.708086 | 0.241478 | 0.491404 | 7.133403724 |

## Comparison of Information Point Distance (Area Of Influence) and Tonnage Relative Error Method VS SNI 5015:2019

With different total tonnages, this difference can be used as an evaluation of SNI 5015:2019 in order to use geostatistical considerations and provide recommendations for the distance of information points, not only to focus on geological conditions and complexity. It is proven by a geostatistical study in the form of relative error, it can be obtained that the distance of the information point is farther away than the classification based on SNI 5015: 2019, but the relative error method itself is susceptible to the high and low variability of the data so that data preparation is needed first before processing the data so that The data is typically distributed and can be estimated or processed at a different level according to the information needs to be obtained. Meanwhile, the polygon method used by SNI 5015:2019 is a resource estimation method that assumes a value (such as a thickness value) as the average value of a specific block size. For certain conditions,  where the deposit has a good distribution of data, this method will give good results and vice versa; sometimes, the relationship between the data held in a place is farther than the distance set by SNI 5015:2019 itself, and that is what we can see in the results of this study where the distance of influence calculated geostatistically using a coal quality and thickness database in the research location has a more extended range than the classification using only geological complexity.

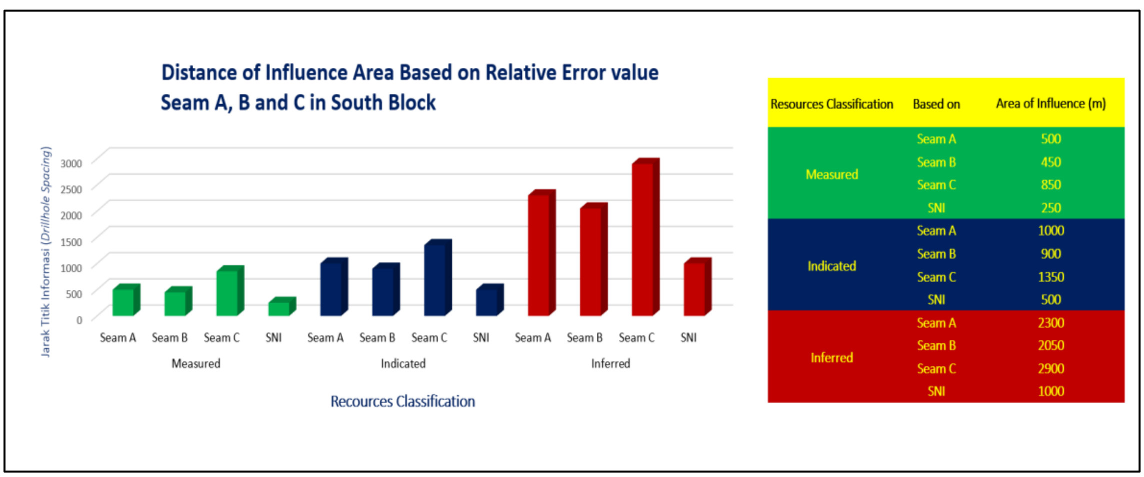



**Figure 5.** Distance of Influence Area Based on Relative Error value Seam A, B and C

The total accumulation of measured and indicated resources using the relative error method is 4,434,692 million tons more than using the SNI 5015:2019 polygon method. This difference occurs because there are inferred resources in the resource classification using the SNI 5015:2019 method. Meanwhile, the estimated total coal resources in the research area are 134,681,294 million tons, with the surface model limit for deposits is topography limit end of mine 2021.

**Table 6.** Resource Tonnages Classification SNI 5015:2019 vs *Relative Error*

| Methods | Classification | | | | Total Sumberdaya |
|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Measured and Indicated | |
| *Relative Error* | 129,080,731 | 5,600,563 | 0 | **134,681,294** | 134,681,294 |
| SNI 5015:2019 | 104,644,384 | 25,602,218 | 4,434,692 | **130,246,602** | 134,681,294 |

## CONCLUSION AND FURTHER RESEARCH

Based on the Drill Hole Spacing Analysis (DHSA) with the Global Estimation Variance (GEV) method, the optimal distance information points (borehole spacing) for each seam are:

a) Seam A with measured resources of 500 m at 10% relative error, indicated at 1000 m at 20% relative error, and 2300 m inferred at 50% relative error.

b) Seam B with measured resources of 400 m at a relative error of 10%, indicated by 900 m at a relative error of 20%, and inferred by 2050 m at a relative error of 50%.

c) Seam C with measured resources of 850 m at a relative error of 10%, indicated by 1350 m at a relative error of 20%, and inferred by 2900 m at a relative error of 50%.

Based on statistical and geostatistical analysis, which was also carried out by considering the degree of confidence (confident level) based on the amount of data compared to other seams, the drill hole spacing was chosen from seam B as a recommendation for optimal borehole spacing for the continuous exploration drilling process, with a distance of 450 m for the measured resource class, 900 m for the indicated resource class and 2050 m for the inferred resource class. From the comparisons made, it is known that there are differences in the total accumulation of measured and indicated resources; in the indicated and measured resource relative error methods, the relative error method is 4,434,692 million tons more than the SNI 5015:2019 polygon method with moderate geological conditions, this difference occurs due to differences in the range of point distances. Information from the two methods so that there is an inferred resource in the resource classification with the SNI 5015:2019 method due to the smaller distance of the information point in that method. An evaluation of SNI 5015:2019 is needed to accommodate other important aspects such as geostatistics in making information point distance determinations in the coal resource classification system. The combination of geostatistical methods accompanied by the interpretation of the relevant geological models in the estimation and classification of resources is very necessary so that the classification and estimation results obtained follow the conditions in the field. It is not necessary to add drill holes to increase the data density because the distance of the existing drill holes, which is on average at a distance of 150 - 300 meters, is closer than the most optimal drill hole distance classification of 450 m with a radius of 225 m based on the relative error value from the analysis. Drillhole Spacing Analysis (DHSA). Based on this justification, the distance between drill points should be expanded to save drilling costs in the research area.

It is advisable to do further geostatistical research in the research area regarding other quality parameters such as total sulfur and ash content which in this research area has relatively poor data regularity and has a high variance value.

## ACKNOWLEDGMENTS

I would like to thank for those who have provided the opportunity to conduct this research.

## REFERENCES

1. Annels, A.E. 1991. Mineral Deposit Evaluation: A Practical Approach.Netherl ands: Springer.
2. Badan Standarisasi Nasional Tentang Pedoman Pelaporan Sumberdaya, dan Cadangan Batubara, SNI 5015:2019.
3. Bertoli, O., Paul, A., Casley, Z., dan Dunn, D. 2013. Geostatistical Drillhole Spacing Analysis for Coal Resource Classification in the Bowen Basin, Queensl and. International Journal of Coal Geology 112, pp. 107-113.
4. Coalfields Geology Council of New South Wales dan the Queensland Resources Council. 2014. Australian Guidelines for The Estimation and Classification of Coal Resources, 2014 Edition. Sydney, Australia.
5. Cornah, A., Vann, J., dan Driver, I. 2013. Comparison of three geostatistical approaches to quantify the impact of drill spacing on resource confidence for a coal seam (with a case example from Moranbah North, Queensland, Australia). International Journal of Coal Geology 112, pp. 114-124.
6. De Souza, Costa and Koppe, Uncertainty Estimate in Resourches Assesment: A Geostatistical Contribution, International Association for Mathematic al Geology, 2004.
7. Diehl, P. and David, M., Classification of Ore Reserve/Resources Based on Geostatistic al Methods, CIM Bull, 1982.
8. Erika. 2017. Drill Hole Spacing Analysis with Geostatistics in Coal Resource Evaluation. ITB, Bandung.
9. Wintolo, Djoko. (2019). Introduction to Statistics and Geostatistics. Yogyakarta : Gadjah Mada University Press.