Determination Of Geomagnetic Data Measurement Point Spacing By Geostatistic Approach

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***Abstract*—Exploration activities can not be separated from the measurement of geomagnetic method. Geomagnetic method is one of geophysical method that is often used and does not require big cost in exploration activity of tin. The use of geomagnetic method tools is very effective to reach a wide scale with a variety of measurement site terrain as well as data measurements of geomagnetic method can help analyze the state of the subsurface. Overview of the Earth's surface measurements of geomagnetic methods depends on the determination of point spacing measurement. Spacing point measurement geomagnetic methods typically use spacing of 20 meter. Determination of spacing of measurement points need to be tested using the comparison of spacing of 10 meter, 30 meter, 40 meter, and 50 meter with geostatistic approach (kriging). The measurement data of geomagnetic method used is Total Magnetic Intensity (TMI) value. The result of the geostatistical approach to the geomagnetic point spacing measurement point is expected to provide an alternative use of effective measurement point spacing in the exploration activities. The 40 meter spacing between geomagnetic measurement points shows a pattern that its almost the same as a 10 meter spacing with a level of confidence (r) that its higher than spacing of the confidence with 0.529 value.**

Keywords—Exploration, Tin, Geomagnetic, Geostatistical, Spacing

I. Introduction

The province of the Bangka Belitung island is including a tin belt line that has a large measure of tin (Casitterit-SnO_2). Exploration is part of a mining stage with a purpose to knowing the quantity of resources or deposits of mineral below the ground with various methods and avoiding the loss that the company will endure[1]. Exploration activities provide potential measurable possibilities to support the mining data. Available untapped potential, so a variety of exploration activities were done to get a representation of lead dispersion of tin below the ground.

Geomagnetic method is a passive and often used geophisical method to describe conditions under the ground by seeing the discrepancy of the rock value that is interpreted in a way to separate the rocks of the magnetic and that wasn’t local to the length of the measurements. Geomagnetic method doesn’t require a large cost in doing exploration activities.

The determination of spacing between points of measurment of geomagnetic data considering the accuracy by the result, Generally the length of the spacing is 10 meter between the measurement points assuming the spacing of the measurement point represents the local condition below the surface based on the difference of the susceptibility rock value.

The distance spacing of the measurment point of geomagnetic method needs to be analyzed with the approach of the geostatistical method (kriging). The analysis is done by comparing the spacing between points of measurment 10 meter, with 20 meter, 30 meter, 40 meter and 50 meter. The spacing selection of 10 meter multiple measurment point is expected to provide effective knowledge of spacing between measuring points to describe the conditions below the surface of primary tin deposits whose interpretation results aren’t much different from the 10 meter point spacing. This is done to make the effective time and costs of exploration activities.

II. Literature Review

A. Geomagnetic Method

Geomagnetic method or magnetic method is one of the geophysical methods for subsurface (underground) exploration of the earth which is widely used to explore minerals and rocks[2]. Geomagnetic method is one of the geophysical methods that used for preliminary survey on petroleum exploration, geothermal, rock, mineral and volcano monitoring purpose. Geomagnetic method can be used to determine the depth and the structure of the surface, so the measurement can be obtained easily for local and regional studies[3].

The nature of rock magnetization or susceptibility in various rocks depends on the rock itself which is grouped as follows:

1. Diamagnetic, which is a mineral that has a negative magnetic susceptibility with the meaning is the oerbits of electrons in this object are always opposite to the magnetic field from the outside. The excample is graphite, marble, quartz and salt.
2. Paramagnetic, which is a mineral that has a positive magnetic susceptibility price and a small value. The excample is acid sulfuric rocks.

3. Ferromagnetic, which is a mineral that has a large magnetic susceptibility value. The excample is alkaline or ultra ignous rocks.

In geomagnetic surveys in the field generally use minimum two magnetometer devices. The first tool measures variation daily which aims to measure the influence of magnetic fields from the outside of the earth(FVH), while the second tool is used to measure predetermined trajectories. Other than that the earth's main magnetic field is calculated based on the IGRF value (International Geomagnetic Reference Field) of each location (FIGRF), the value obtained from the results of field measurements is called (Fobs), where this value is still mixed with the influence of the magnetic field from inside and outside the earth with nanoteslan units (nT). Magnetic anomalies observed were written with the following equation [4]:

$$\Delta F = F_{obs} - F_{IGRF} \pm F_{VH} \quad (1)$$

The basis for reviewing the anomaly of the geomagnetic method is the coulomb force between two magnetic poles of m1 and m_2 which are spacing *r* with the same eqution as follows [5]:

$$F = \frac{m_1 m_2}{\mu_0 r^2} r \quad (2)$$

where F is the force acting between two magnets with magnetic field strength of m_1 and m_2. μ is the permeability of a medium with Henry units per meter (H/m). In a vacuum medium absolute permeability equals μo whose value 4π x 10^{-7} H/m. μ0 constant is permeability for dimensionless vacuum. The amount unit is 4πx10-7 Newton/Ampere^2 [6].

B. Geostatistic Method

Geostatistics is the development of statistical science applied in geology and earth science in generall. The basic principle of geostatistics is that the measurement points that are close together will tend to have value weights that are not much different comapare to the measurement points that are far apart, in other words estimating the value of the characteristics of the estimator ($\overline{Z}_{Xo}$) at the point that is not sampled based on information from the surrounding points [7]. This method is a special method in a weighted moving average that minimizesthe variance from the estimation results [8].

The geostatistical method is part of a modern assessment method which is one of the deep geostatistical calculations produce predictions or minimum errors (kriging variance) from each data point (sample). This method estimates a point that is not is sampled based on the sampled data points those around him consider the results of spatial correlation[9].

Kriging is an estimation method that provides BLUE (Best Linier Unbiased Estimator) estimator of point values or block averages. This estimation method considers the factors that affect estimation accuracy is : the number of samples, the position of sample, the distance between samples with the point to be estimated, and the spatial continuity of the variables involved.

The kriging estimate ($\overline{Z}_{Xo}$) with x_0 is linear combination from random variable x_i [10], can be written as:

$$\overline{z}(x_0) - m = \sum_{i=1}^{k} [\lambda_i z(x_i) - m] \quad (3)$$

where m is the mean value, λ_i represents the weighted $z(x_i)$ for estimation x-location, x_i different of location vector and *k* number of sample points.

III. Methodology

A. Field Measurement

Field measurements were carried out using the base-rover method (2 Proton Procission Magnetometer (PPM) devices where 1 PPM tool was placed at a noise-free point and 1 PPM for measuring points), spacing 10 meter between 10 measurement points with the distance between lines is around 50 meter. The value obtained from the results of field measurements is the value of the magnetic field, time, and coordinates. The value of the temporary magnetic field is then corrected to get the value of Total Magnetic Intensity (TMI) geomagnetic data.

B. Data Processing

The data obtained is corrected to the magnetic field data while the measurement results at each point consisting of daily corrections, International Geomagnetics Reference Field (IGRF) so that the value of Total Magnetic Intensity (TMI) geomagnetic data is analyzed by the influence of the distance between the measurement points with the geostatistical method approach (kriging).

C. Data Interpretation

TMI data from kriging results are then displayed in the form of a pattern map of the distribution of total magnetic field anomalies (TMI) geomagnetic value between the spacing of the measurement points. Then cross-validation is done to see the level of confidence in the estimated spacing of the measurement point.

IV. Results and discussion

A. Geomagnetic Measurement Elevation

Geomagnetic measurements have the highest elevation of 119 meter while the lowest elevation is 26 meter. Geomagnetic measurements directed South-North by following the elevation of the study location.

The track is 10 lines with a spacing of 10 meter and a line interval of about 50 meter. The location of geomagnetic measurements is in the area of Sambung giri hill (Fig. 1).

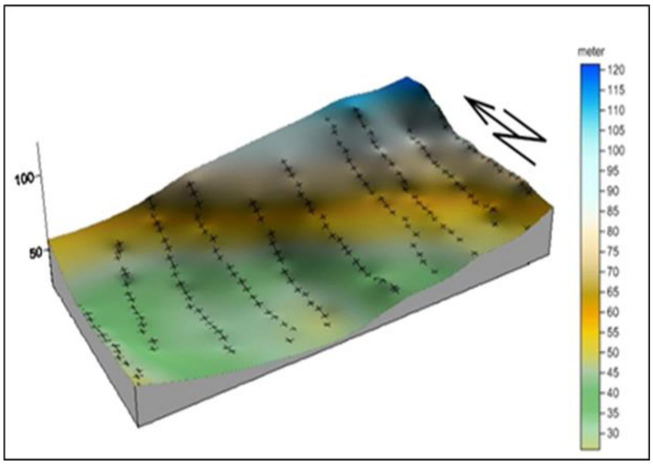

Fig. 1. Distribution line of measurement points geomagnetic to elevation

B. *Univariate Grid Statistics For TMI Geomagnetic Data*

Unvarian statistical analysis is used for describes the distribution of variables single that is displayed such as histogram. Unvarian TMI statistical grid analysis geomagnetic value shows coefficient values of 40 meter spacing smaller than spaces between other measurement points (Table 1).

The coefficient of variation shows the small difference in changes between TMI geomagnetic value so that the TMI geomagnetic value can still be used to assess TMI geomagnetic value.

The distance between spacing of measurement points does not need to be treated data such as percentiles or grouping TMI geomagnetic value based on the influence of distance between spacing.

Univariate grid statistics for TMI geomagnetic value obtained standard error (SE) value of 0.428 at 40 meter spacing with a smaller amount of geomagnetic data. Contrast susceptibility value of rock is influenced by the spacing of the distance between the measurement points. The tendency of TMI geomagnetic value to be spread to the right with a kurtosis value of 2,163 nT.

TABLE 1. UNIVARIATE GRID STATISTICS FOR TMI GEOMAGNETIC VALUE

Input	Parameters (Output)	Spacing/ interval of measurement point				
		10	20	30	40	50
TMI	N (data)	184	93	66	54	46
	Standard Deviation	30.9899	31.72945	31.27171	30.88144	32.47334
	Standard Error	0.429753	0.440008	0.433661	0.428248	0.450324
	Coefficient of Variation	0.000724	0.000741	0.000731	0.000722	0.000759
	Skewness	-0.52376	-0.53955	-0.43142	-0.43806	-0.47703
	Kurtosis	2.409272	2.294823	2.227855	2.163772	2.17909

The variogram model of the TMI geomagnetic value used is spherical. The selected variogram model shows the form of variogram graphs on the spacing between the same measurement points.

Variogram model parameters obtained are then used to estimate the TMI value. The results of estimating the TMI geomagnetic value using computer software. The results of the assessment of the TMI geomagnetic value using a geostatistical approach (kriging) obtained the estimated value, then the TMI data is described in accordance with the spacing between the measurement points so as to provide information on the location of the blocks of low to high susceptibility values. The variogram chosen in this study uses isotropic variogram. The results of a valid variogram spatial analysis of the TMI geomagnetic value are shown in Fig. 2.

From the measurement results show that at a distance of 40 meter the high TMI value is locally located (north) with values above 42815 nT showing orange to red color while the small TMI geomagnetic value is below 42750 nT which lies wide from the Southeast thinning to the Northwest (blue) in Fig. 2. In general, the TMI geomagnetic value did not show differences of distribution pattern as in the spacing of 10, 20, 30, 40 and 50 meter.

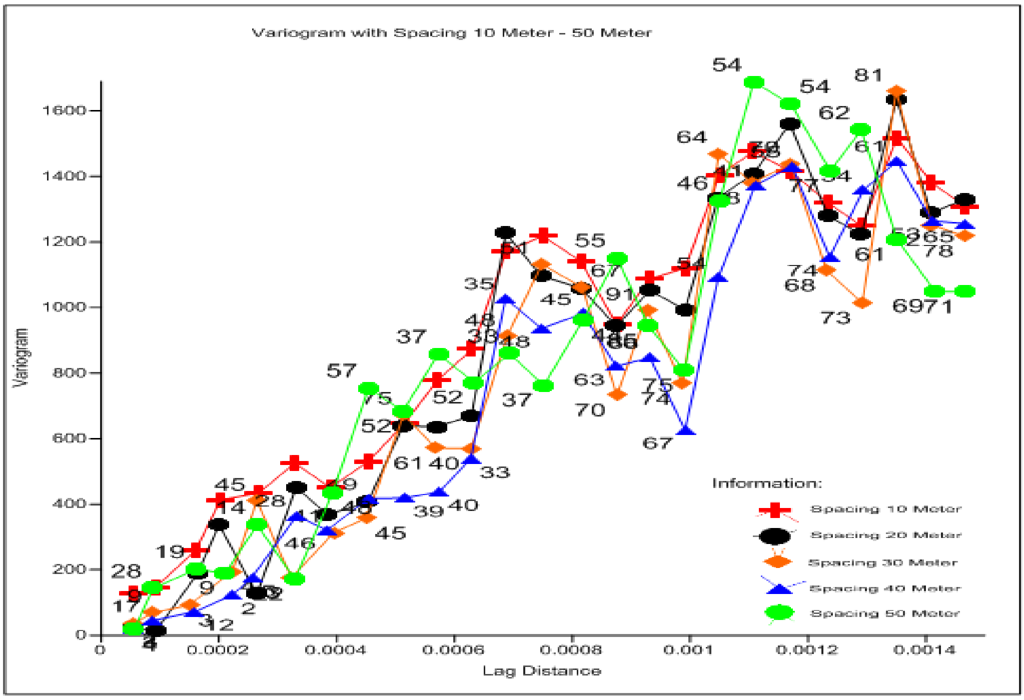

Fig. 2. Variogram graph of TMI geomagnetic value

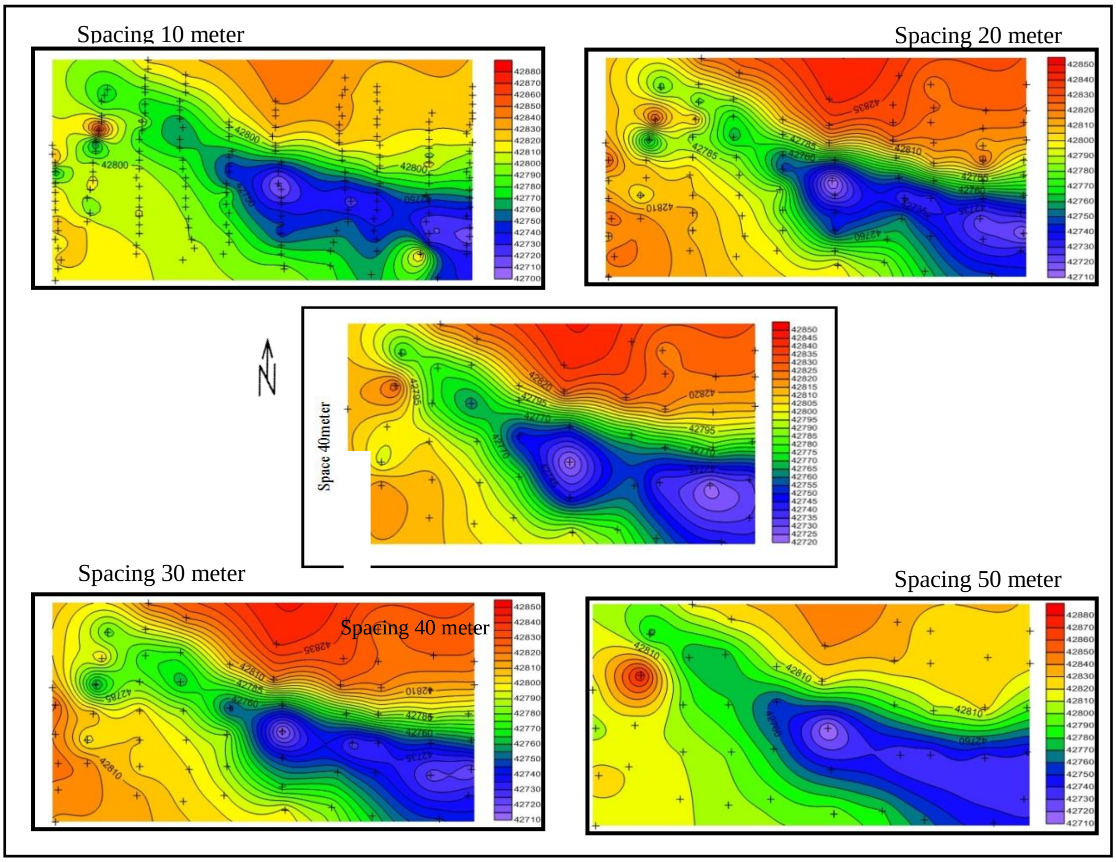

Fig. 3. The results of geostatistical method with approach to TMI geomagnetic data

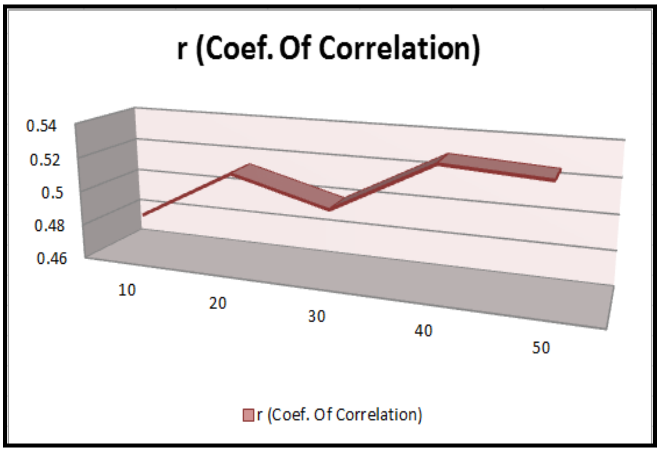

Fig. 4. Graph of confidence level of interval data of measurement point

The results of TMI geomagnetic value assessment using a geostatistical (kriging) approach were then cross-validated. This test is conducted to determine the level of accuracy of an assessment obtained. Perform a model suitability test (cross-validation) to find out whether the model is valid and can be used to estimate. The result cross-validation from TMI value show in Fig. 4.

The cross-validation parameter of the TMI geomagnetic value shows that the relationship between the data is not much different between the spacing of the measurement points where the 40 meter spacing has a confidence level of 0.529 (r).

The relationship of cross-validation that does not reach 90% can be caused by random distances between measurement points and the complex geological structure that exists in the research location. The parameters of the cross-validation results of the TMI geomagnetic data are shown in Table 2.

TABLE 2. THE LEVEL OF CONFIDENCE FOR TMI GEOMAGNETIC DATA

Interval (meter)	Coefficient Of Correlation (r)
10	0.484
20	0.514
30	0.499
40	0.529
50	0.525

V. CONCLUSIONS

The results analysis of the spacing between the measurement points of the geomagnetic method with the geostatistical method approach concluded that the effective spacing between measurement points is 40 meter with the confidence level of the resulting data is 0.529 higher than the others spacing.

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REFERENCES

[1] Notosiswoyo, Sudarto., *Teknik Eksplorasi*, Program Studi Teknik Pertambangan: Institut Teknologi Bandung, Jawa Barat, 2010.

[2] Sharma, P.V., *Environmental and Engineering Geophysics:* Cambridge University Press, 1997.

[3] Burger, Henry Robert., *Exploration Geophysics of the Shallow Subsurface,* New Jersey: Prentice Hall, 1992.

[4] Cressie, N. A. C., *Statistics For Spatial Data,* New York*:* John Wiley and Sons, Inc., 1993.

[5] Telford, W.N., Geldard, L.P., Sherrif, R.E., and Keys, D.A., *Applied Geophysics,* New York: Cambridge University Press, 1979.

[6] Dobrin, M.B., *Introduction to Geophysical Prospecting,* New York: Mc Graw Hill Book Company, United States of America (USA), 1960.

[7] Suprajitno, Munadi., *Pengantar Geostatistik*, Jakarta: Universitas Indonesia, 2005.

[8] Olea, Ricardo,A., *Geostatistics for Engineers and Earth Scientists*: Kluwer Academic Publishers, United States of America (USA), 1999.

[9] Cressie, N. A. C., *Statistics for Spatial Data,* New York: Resived Edition, John Willey & Sons, Inc., United States of America (USA), 1993.

[10] Armstrong, Margaret., *Basic Linear Geostatistics,* New York: Springer-Verlag, Berlin Heidelberg, United States of America (USA), 1998.