International Journal of Recent Trends in Engineering & Research

ISSN (ONLINE) : 2455 – 1457 IMPACT FACTOR : 4.101

IDENTIFICATION OF THE GEOLOGICAL STRUCTURE OF SEMARANG CITY
(BASED ON GRADIENT AND EULERDECONVOLUTION ANALYSIS)

Lilia R[1], M. Irham Nurwidyanto[1], Tony Yuliantio[1], Sugeng Widada[2], DadanDani Wardhana[3]

[1] *Department of Physics, Faculty of Science and Mathematics, Diponegoro University, Semarang*
[2] *Department of Oceanography, Faculty of Fisheries and Marine Sciences, Diponegoro University, Semarang*
[3] *Geotechnology Research Center LIPI Bandung*

ABSTRACT Gravity data processing has been carried out in the Semarang, Central Java area with measurements made by the La Coste & Romberg gravity meter as many as 71 points scattered in the lower and surrounding parts of Semarang. This study aims to identify the geological structure in the research area. In this study used gradient analysis consisting of first horizontal gradient, second horizontal gradient, first vertical gradient and second vertical gradient to identify the geological structure in the study area. And using additional methods namely Euler Deconvolution analysis to estimate the depth of the geological structure. The results obtained from the study indicate that the existing geological structure in the form of a fault from the gradient analysis is in the southwest which traverses northwest-southeast. While the results of Euler Deconvolution, the average depth of the fault is 100 meters to 1500 meters.

Keywords: gravity method, gradient analysis, Euler de-convolution

I. INTRODUCTION

Semarang is a City morphologically can be grouped into large from north to south can be grouped into three units, namely terrestrial morphology, temperate hills morphology and high hills morphology. The northern part is a lowland forming weak corrugated hills, the middle part is a medium wavy hill that extends from west to east, and the southern part is a plateau that shows high and steep morphology [1].

The geological structure found in the city of Semarang is generally a fault consisting of a upward fault, normal fault and shear fault. Research on the identification of active faults along the Kaligarang, states that in the study area there are several fault lines were identified, one of which was a north-south trending fault commonly called the Kaligarang Fault [2]. Based on the results of qualitative analysis of bouguer anomalies and residual anomalies, it is shown that the structures that developed in the study area generally traverse east-west and north-south [3].

This study aims to further identify the fault structure in the Semarang area using the gravity method approach through horizontal gradient analysis, vertical gradient and Euler deconvolution.

Gradient analysis in the gravitational method is very effective in identifying fault structures, where First Horizontal Gradients play a role in determining the boundaries of fault structures, and Second Vertical Gradients play a role in identifying the type of fault [4]. The Euler deconvolution analysis to strengthen the results of gradient analysis is accompanied by the presence of anomalous depth estimates. The results of the interpretation of this method are expected to be one of the references to improve knowledge and understanding of cesarean delivery, especially regarding the fault structure in the study area.

II. THEORY

The gravity method is one of the geophysical methods based on the measurement of the gravitational field. In this method which is studied is the variation of the gravitational field due to variations in rock mass density below the surface so that the implementation investigated is the difference in the gravitational field from an observation point to another observation point. Usually in this gravity measurement work, looping is done [5].

2.1. Horizontal Gradient

Horizontal gradients are used to emphasize the high anomalies contained in gravity data, because the maximum values that show lateral density in contrast are indicated as faults. The horizontal gradient (x, y) is defined by equation (2.1) [6];

$$\boldsymbol{HG}\ (\boldsymbol{x},\mathrm{y}) = \sqrt{\left(\left(\frac{\partial \Delta \mathrm{g}(\mathrm{x,y})}{\partial \mathrm{x}}\right)^2 + \left(\frac{\partial \Delta \mathrm{g}(\mathrm{x,y}}{\partial \mathrm{y}}\right)^2\right)} \qquad (2.1)$$

The value of Δg is the total gravity Bouguer value, ∂x is the x-axis gradient value and ∂y is the y-axis gradient value.

2.2. Vertical Gradient

Vertical gradient method can be used to help interpret the type of structure against Bouguer anomaly data which is caused by the presence of a broken or upward fault structure.
The second vertical for the gradient of the equation corresponds to the following equation (2.2)[6];

$$\frac{\delta^2 \Delta g}{\delta z^2} = -\left(\frac{\delta^2 \Delta g}{\delta x^2} + \frac{\delta^2 \Delta g}{\delta y^2}\right) \qquad (2.2)$$

2.3. Euler De-convolution

Euler De-convolution is one of the geophysical exploration methods used to estimate the position and depth of anomalous objects from a gravitational potential field as well as lithology boundaries [7]. Euler De-convolution uses a mathematical approach to estimate the depth of an object based on a three-way partial derivative (x, y, z) of a function. In general, the Euler equation can be formulated as follows [7]:

$$(x - x')\frac{\partial g}{\partial x} + (y - y')\frac{\partial g}{\partial y} + (z - z')\frac{\partial g}{\partial z} + (g - b) = 0 \qquad (2.3)$$

Where the Valueof $\frac{\partial g}{\partial x}$, $\frac{\partial g}{\partial y}$, $\frac{\partial g}{\partial z}$ is the derivation of gravity data in the direction of x, y, z. $\boldsymbol{\eta}$ is a structure index.

2.4. Geology of Semarang area

The study area was largely covered by the Damar Formation which was of the Plistocene age and along the northern coast by alluvium deposits. Based on the Geological Map of the Semarang Magelang Sheet shown in Figure 1, the stratigraphic arrangement of the study area in Semarang City is composed of the Kerek Formation, Kalibeng Formation, Damar Formation, KaligetasFormationand Alluvium.

The geological structure in the Semarang area is generally in the form of a fault consisting of a normal fault, shear fault and up fault. These faults generally occur in theKerek Formation rocks, Kalibeng Formation and quarter and tertiary Damar Formations [8].

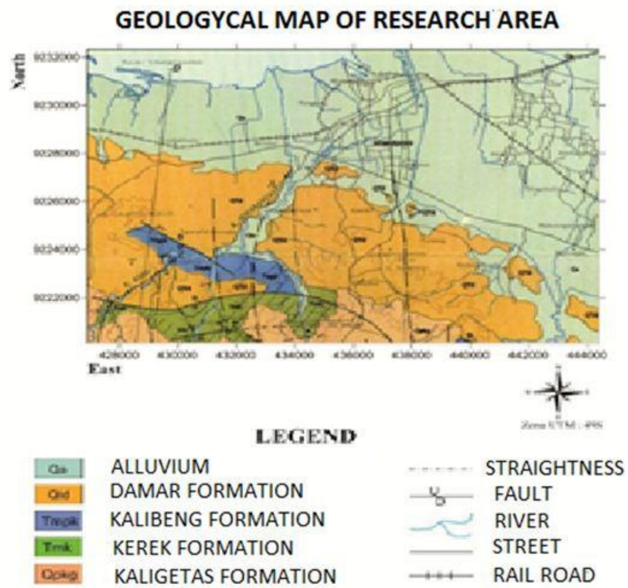

Figure 1 Geological map of the study area [8]

III. RESEARCH METHOD

The gravity data measurement was carried out in the Semarang area using the Lacoste Romberg gravimeter G1118 MVR gravity meter measuring the location altitude using Differential GPS Trimble 4600 LS with interval measurement points from 1 km up. 2 km. In this study, the measurement trajectory has a road that already exists in Semarang City. The study was conducted with a looping system for correction of drift and tides. The data used in the form of Bouguer Anomaly data complete the study area as many as 71points.Complete Bouguer anomalies obtained are still mixed data. So that anomalies are separated using the upward continuation method. Complete Bouguer anomaly is used as input in conducting gradient analysis, which then results from the gradient analysis as input for Euler de-convolution calculations. In this research, second vertical gradient data is used as input data in the calculation of Euler de-convolution, because the second vertical gradient method is a good method within the boundaries of rock lithology and determines the location of fault structures.

IV. RESULTS AND DISCUSSION

4.1. Complete Bouguer anomaly

Complete Bouguer anomaly data is depicted in contour form as shown in Figure 2. Low anomalies (-2.9 to 6.8 mGal) are scattered to the southwest of the study area. Moderate anomalies (6.8 to 10.8 mGal) spread extensively from south to northwest. High anomalies (10.8 to 13.4 mGal) are in the middle extending eastward and slightly turning southeastward from the study area.

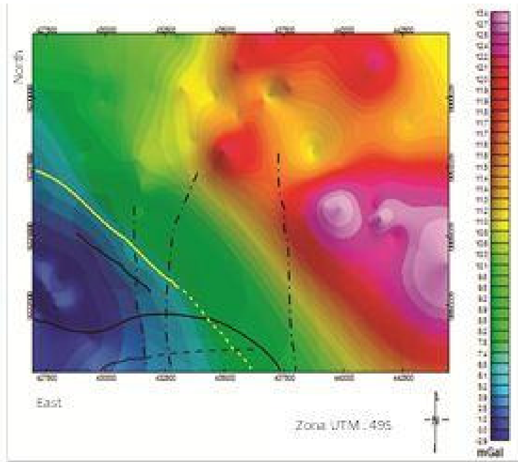

Figure 2.Bouguer anomaly map

4.2.Regional Anomaly and Residual Separation

The bouguer anomaly that is obtained is still a combination of regional anomalies and residual anomalies, it is necessary to have a separation between the two anomalies. The goal is to find out the source of internal anomalies and superficial anomaly sources that affect the bouguer anomaly. In separating this anomaly is done by the method of upward continuation.

Regional anomalies shown in Figure 3A, and the residual anomalu as shown in Figure 3B. The regional anomaly have a value range of 2 mGal to 12.7 mGal where the distribution of values is not much different from the bouguer anomaly. This is because the most dominant effect on bouguer anomalies is superficial residual effects.

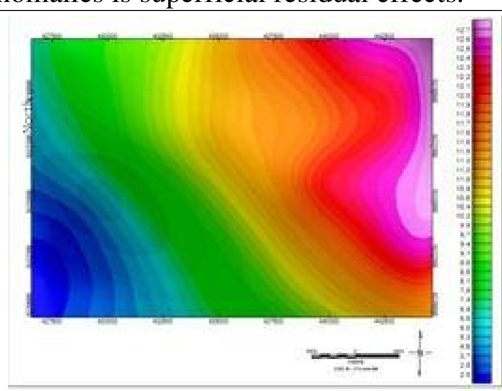

Figure 3A, Regional anomaly map

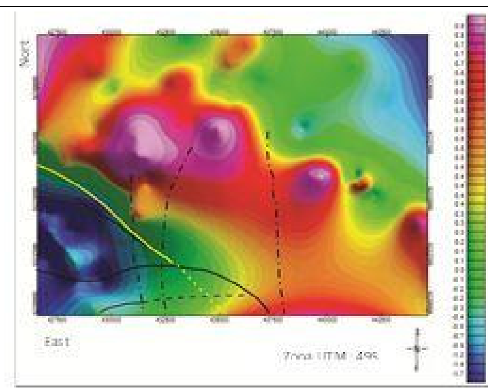

Figure 3 B , Local anomaly map

Based on Figure 3B, there is increasingly clear color contrast in the southwest, where there are high-value and low-value anomalies separated by medium-value green anomalies. The difference in the anomaly is estimated to be controlled by a fault trending northwest-southeast shown in yellow.

4.3. Horizontal Gradient

Figure 4 shows the distribution of the value of the first horizontal gradient of the study area which has a distribution between 0.0 mGal/m to 0.00527 mGal/m. The first horizontal gradient value estimated as the fault location is indicated by the distribution of high (maximum) values [9][10], in the study area indicated by the yellow line. This fault is northwest - southeast. The white line is indicated as lithology boundary.

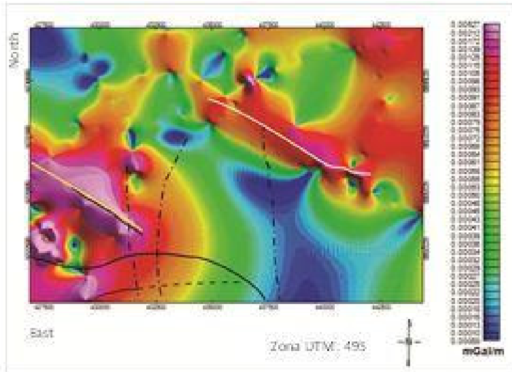

Figure 4first horizontal gradient Map

4.3.Vertical Gradient

The results of the first vertical gradient and second vertical gradient are shown in Figure 5A and Figure 5B.

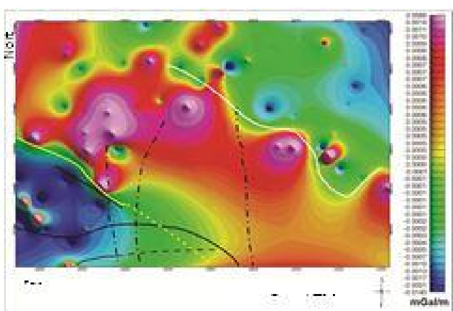

Figure 5A First vertical gradient Map

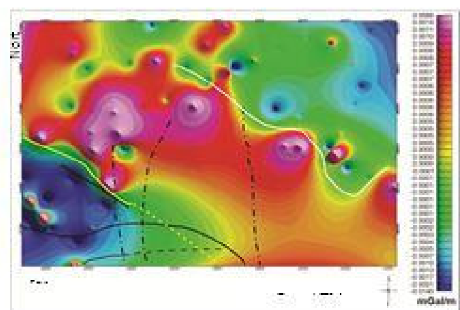

Figure 5B Second vertical gradient Map

Figure 5A shows the distribution of the value of the first vertical gradient of the study area which has a distribution of values between -0.0140 mGal/m to 0.0088 mGal/m. While Figure 5B shows the distribution of the second vertical gradient value of the study area which has a distribution of values between -0,0002301mGal/m to 0,0001927 mGal/m.

The second vertical gradient value which is estimated as the location of fault is indicated by a distribution that is worth zero[10]. In the study area (Figure5) which is shown by a yellow line that trails northwest-southeast. The white line (Figure 5) is estimated as an indication of lithology limits.

4.4.Euler Deconvolution

The process of interpreting the results of Euler Deconvolution is overlaid with a second vertical gradient map to estimate the depth of the geological structure represented by Figure 6. The second vertical gradient map is used because the second derivative method is vertically quite good in identifying faults because the contact limits of rocks are clearly visible .

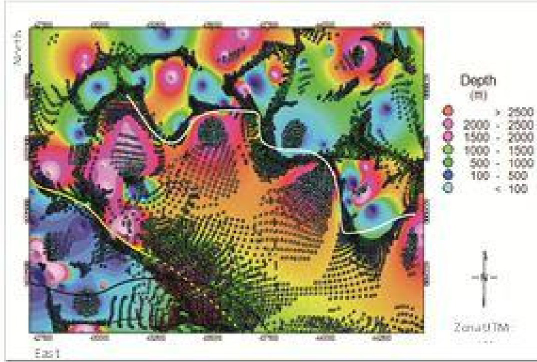

Figure 6 Overlay of Euler de-convolution results with a second vertical gradient map

The result of the fault interpretation based on Euler deconvolution is shown by the yellow line in Figure 8. The Euler deconvolution results in other parts namely in the north extending east and west, are indicated as lithology boundaries which can be seen on the geological map of the study area.Based on the results of the Euler Deconvolution analysis shown in Figure 8, the faults seen have an average depth of 100 meters to 1500 meters. While lithology boundaries have depths ranging from 100-500 meters.

The results of the interpretation of the three methods namely first horizontal gradient, Second vertical gradient and Euler deconvolution were overlaid into one on the geological map of the study area (Figure 7).Based on Figure 7 the red line is a fault interpretation based on first horizontal gradient, yellow is a fault interpretation based on first vertical gradient, blue is a fault interpretation based on second vertical gradient, while green is a fault interpretation based on Euler deconvolution. Based on the methods carried out, the fault indications that are closest to the geological map are the first horizontal gradient and second vertical gradient methods. So it can be concluded that the method of first horizontal gradient and second vertical gradient is a good method in the interpretation of faults. While the Euler de-convolution method in this study is used as an additional method for estimating depth.

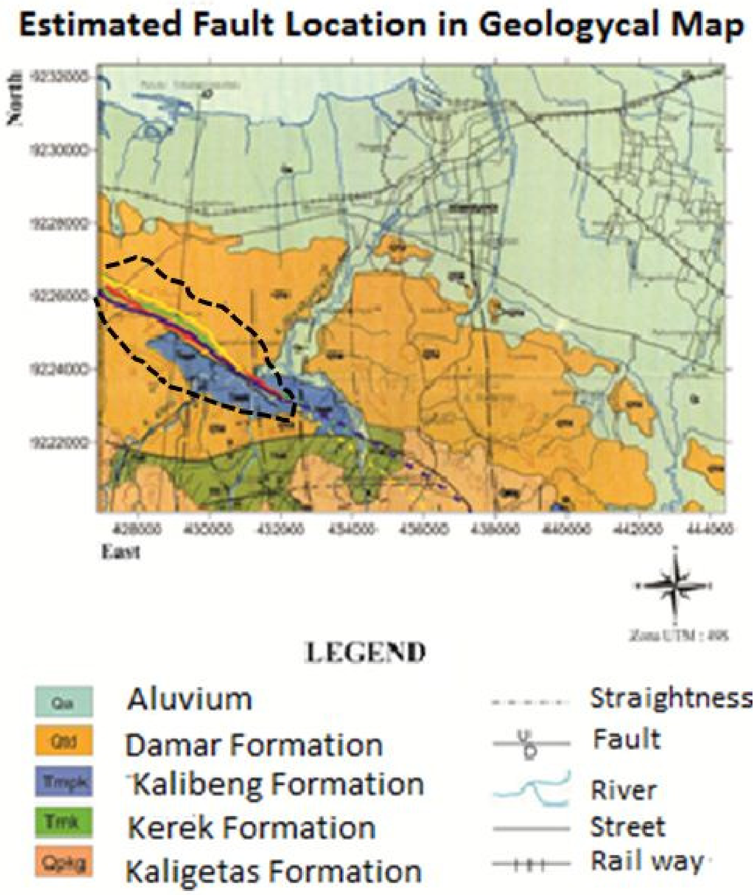

Figure 7 Overlay geological maps with faults Results of interpretation

V. CONCLUSION

Gradient analysis has been carried out which includes first horizontal gradient, second horizontal gradient, first vertical gradient, and second vertical gradient, and Euler deconvolution. The results of horizontal gradient, vertical gradient and Euler deconvolution indicate the existence of a geological structure in the form of a fault located southwest of the study area. The fault is directed northwest-southeast. The results of Standard Euler De-convolution show that the structure seen from gradient analysis has an average depth of 100 meters to 1500 meters. While the lithology boundary has a depth of 100 meters to 500 meters.

VI. REFERENCE

[1]. Tama, S.K., 2015. Ground Surface Structure in the Old City of Semarang Using the Geoelectric Resistivity Method Schlumberger Configuration.Encryption.FMIPA, Physics Department, Semarang State University.

[2]. Wardhana, D.D. ,Harjono, H., Sudaryanto, 2014. Underwater Structure of Semarang City Based on Gravity Data. Geology and Mining Research Vol. 24 No. 1

[3]. Nainggolan, D.A., 2008. Underwater Structures of Semarang Area and Surrounding Areas From the Methods of Weights and Magnets and their Relation to Geological Resources. Journal of Geological Resources, Vol. XVIII No. 3.

[4]. Hartati, A., 2012. Identification of Fault Structures Based on Derivative Analysis of the Gravity Method in Sulawesi Island.Description.FMIPA, Physics Study Program, University of Indonesia.

[5]. Supriyadi, 2009. Study of Relative Gravity in Semarang. Journal of Indonesian Physics Education 5, ISSN: 1693-1246.

[6] Blakely, R.J., 1995, *Potential Theory in Gravity and Magnetic Applications*, Cambridge Univ Press, New York

[7] Reid, A. B., Allsop, J.M. Granser, H., Millett, A. J., and Somerton. I. W., 1990 ,*Magnetic Interpretation in Three Dimensions Using EulerDeconvolution*:*Geophysics*, 55, 80-90

[8]. Thanden, R.E., Sumardidja, Richards, P.W., Sutisna, K., and Amin, T.C., 1996, Geological Maps of Sheets Magelang and Semarang Java, scale 1: 100,000, P3GL, Bandung.

[9]. Latifah, I., 2010. Determination of Bouguer Anomalies and Average Density of Rocks Based on Gravity Data in Semarang Region.Description.Faculty of Science and Technology, Physics Study Program, SyarifHidayatullah Islamic University.

[10]. Nettleton, L.L., 1976. Gravity and Magnetics in Oil Prospecting. New York: McGraw-Hill.